# Demo: Pyrrho DBMS and concurrency

Malcolm Crowe, 25 Oct 2022

This demo is updated from a <u>tutorial</u> at DBKDA 2021.

We look in detail at Pyrrho's Commit() method for a transaction, and the detection of conflicts.

At the start of Transaction Commit, there is a validation check, to ensure that the transaction still fits on the current shared state of the database, that is, that we have no conflict with transaction that committed since our transaction started.

If that is the case, we can relocate all our proposed changes to come after the committed transactions.

The tests for write-write conflicts involve comparing our list of physicals with those of the other transactions. For checking read-write conflicts, we collect "read constraints" when we are making Cursors.

## Part 1: Setting up the demo

Use Visual Studio to open the solution in Pyrrho's src\Shared folder. In the Solution properties, under Debug>Command Line Arguments, enter -d: followed by a suitable database folder such as \DATA. The folder should not contain a file t10. (The command windows are coloured for clarity in these notes: you don't need to colour your windows.)



Also ensure that in the Debug>Options.. window,



the checkbox Step over properties and operators (managed only) is checked. Click OK.

Click Start.

File     Edit     View       Window     Help       ⓒ     -       ○     10       ○     10       ○     10       ○     10       ○     10	Git Project Build Debug C:\PyrrhoDB70\Pyrrho\src\Shar -d:\DATA Enter to start up_ -d:\DATA Enter to start up_ ioSvr.exe ▼ ☐ Lifecycl	- 0	× Pyrrhos	ivr — □ × IA Live Share 🔊
Integer.cs Pyrrhos Application Build Build Events Debug	Configuration: Active (Debug) Start action		-	Solution Explorer     ▼ ₽ ×       Image: Solution Explorer     ▼ ₽ ×       Search Solution Explor 𝒫     ▼       ✓ Image: Solution PyrrhoSvri     ▶       ▷ Image: Solution Items     ▶
Resources Services Settings Reference Paths	Start external program: Start browser with URL: Start options	-		<ul> <li>✓ E PyrrhoSvr</li> <li>▷ &amp; T References</li> <li>Common</li> <li>▷ &lt; C # BTree.cs</li> <li>▷ &lt; C # CTree.cs</li> </ul>
Signing ▼	Command line arguments: -d:\DATA	/0▲ 1⁄99+	م چ master م	<ul> <li>↓ ~ C # Data Type.</li> <li>↓ ~ C # Integer.cs</li> <li>↓ Shared ▲ </li> </ul>

In the pop-up command window, hit the enter key to start up the server:

File     Edit     View       Window     Help	Git       Project       Build       Debug       C:\PyrrhoDB70\Pyrrho\src\Shared\bin\Debug\PyrrhoS         -d:\DATA       Enter to start up         Pyrrho DBMS       (c) 2022       Malcolm       Crowe and University of the         -0:\DATA       Enter to start up         Pyrrho DBMS       (c) 2022       Malcolm       Crowe and University of the         -0:\DATA       Enter to start up         PyrrhoBMS       (c) 2022       Malcolm       Crowe and University of the         PyrhoBMS       (24 Oct 2022)       Malcolm       Crowe and University of the         DoSvr.exe       -       Ifecyce       Database folder \DATA	e West of	Scotland	× □	× &
Integer.cs PyrrhoS	Svr 🗢 🗙			plorer	
Application Build	Configuration: Active (Debug)			tion Exp	ש <b>- "</b> lor ר
Build Events	Start action			ion 'Pyrrh	noSvr' 📤
Debug	Start project			sternal So plution Ite	ems
Resources			4 -	• PyrrhoSvr	
Services	O start external program:		Þ	₽£ Referen	ces
Settings	Start browser with URL:		1	Commo	on
Reference Paths	Start options			¢ ✓ C# CTre	e.cs
Signing <del>T</del>	Command line arguments: -d:\DATA			▷ ✓ C# Data ▷ ✓ C# Inte	ger.cs
💭 Ready	†↓ 2/0 ▲ 🖉 99+ 🖇	۶ master	- 0	Shared 🔺	Д "

#### Minimise the pop-up command window.

At this point ensure there is no database t10 in the nominated folder.

The command we want to run in both windows is the same: PyrrhoCmd t10. Once we do one of them, the DBMS immediately creates the database as we have seen in demo 1.



#### PyrrhoCmd t10

Command Prompt (Blue) - PyrrhoCmd t10 -	-	×	(Green)	• +		- 🗆	×
Microsoft Windows [Version 10.0.22623.870] (c) Microsoft Corporation. All rights reserved.			ersion 10.0.22623.870] ation. All rights reserved.	+ New ~	X		
C:\Users\Malcolm>cd \pyrrhodb70\pyrrho			\pyrrhodb70\pyrrho	-			
C:\PyrrhoDB70\Pyrrho>PyrrhoCmd t10 SQL>			>	$\leftarrow \rightarrow \checkmark$	$\uparrow$	📒 « Sys.	> DATA
				🚞 D	Name	^	Date
				<u> </u>	🗋 t10		25/10
				п			

From now on, the folder window can be hidden (it does not change).

Command Prompt (Blue) - PyrrhoCmd t10	Command Prompt (Green) - PyrrhoCmd t10	-	×	-		×
Microsoft Windows [Version 10.0.22623.870] (c) Microsoft Corporation. All rights reserved.	Microsoft Windows [Version 10.0.22623.870] (c) Microsoft Corporation. All rights reserved.			ſ		
C:\Users\Malcolm>cd \pyrrhodb70\pyrrho	C:\Users\Malcolm>cd \pyrrhodb70\pyrrho					
C:\PyrrhoDB70\Pyrrho>PyrrhoCmd tl0 SQL>	C:\PyrrhoDB70\Pyrrho>PyrrhoCmd t10 SQL>			<b>*</b>	Sys	> DATA
				^		Date
						25/10

In the blue window, let us create a table (it is called RDC because we will demonstrate read-write conflicts), by giving the following commands:

create table RDC(A int primary key,B char)

insert into RDC values(42,'Life, the Universe')
insert into RDC values(52,'Weeks in the year')
table RDC



That has all been committed, because we are running in auto-commit mode, so the green window will pick it up. It is also running in auto-commit mode, so a new command starts a new transaction, and it will check the current state of the database.

#### table RDC

Command Prompt (Blue) - PyrrhoCmd t10	Command Prompt (Green) - PyrrhoCmd t10	-	×	_		×
C:\PyrrhoDB70\Pyrrho>PyrrhoCmd t10 SQL> create table RDC(A int primary key,B char) SQL> insert into RDC values(42,'Life, the Universe') 1 records affected in t10 SQL> insert into RDC values(52,'Weeks in the year') 1 records affected in t10 SQL> table RDC 	<pre>Microsoft Windows [Version 10.0.22623.870] (c) Microsoft Corporation. All rights reserved. C:\Users\Malcolm&gt;cd \pyrrhodb70\pyrrho C:\PyrrhoDB70\Pyrrho&gt;PyrrhoCmd 110 SQL&gt; table RDC   </pre>			0 2 >> = ^	Sys >	DATA Date 25/1
				_		

This completes the set up for this demo. We will repeat this part of the demo later.

## Part 2: A Write-write conflict

Now we start an explicit transaction in the blue window.

#### begin transaction

Command Prompt (Blue) - PyrrhoCmd t10	—	$\times$	Command Prompt (Green) - PyrrhoCmd t10	—	×
C:\PyrrhoDB70\Pyrrho>PyrrhoCmd t10 SQL> create table RDC(A int primary key,B char) SQL> insert into RDC values(42, 'Life, the Universe') 1 records affected in t10 SQL> insert into RDC values(52, 'Weeks in the year') 1 records affected in t10 SQL> table RDC 			crosoft Windows [Version 10.0.22623.870] ) Microsoft Corporation. All rights reserved. \Users\Malcolm>cd \pyrrhodb70\pyrrho PyrrhoDB70\Pyrrho>PyrrhoCmd t10 L> table RDC 		

If we just relied on auto-commit mode it is very difficult to synchronise an overlap of transactions. For a demo, it works very well to use explicit transactions. Notice that in an explicit transaction the prompt changes to SQL-T>. As long as the transaction is running, we will get these prompts. When the transaction is over, either because of commit, or rollback, or because we have done something wrong, it will go back to SQL>.

We will request conflicting changes to table RDC in these two clients. In the blue window, let's "delete from RDC where A=42", to delete the first row.

#### delete from RDC where A=42



That's in a transaction, so nothing has been written to disk yet.

In the green window, we are still in auto-commit mode and we are going to make an update to the same row, which will be committed straightaway to disk.

## update RDC set B='The answer to the ultimate question' where A=42

This should make the blue window unable to commit its transaction because of the conflict.



In order to see what happens, let us set a breakpoint in the debugger. In Solution Explorer, in the Level3 folder, locate file Transaction.cs and double-click.

File Edit View Git Project Build Debug Window Help	Test Analyze Tools	Extensions	Search 🔎	PyrrhoSvr		×
	🎸 •   📪   👼 📮 🖥 🖬	■ ひ   ↓ ‡	~ ↑   ∦ <sub>=</sub>	;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;	🖻 Live Share	R
Process: [0x3064] PyrrhoSvr.exe	ents 👻 Thread:		- P P	' )⇔ <mark>"</mark>		
Transaction.cs 👍 🗙 PyrrhoSvr				<b>-</b> ‡	Solution Explorer	<b>-</b> ₽ ×
🖙 PyrrhoSvr 🗸 😤 Pyrrho.Level3.Tran	saction 👻 🖳 /	AutoCommit		<b>-</b> ÷	6 🕘 🎧 🎜 🗍	<b>⊙</b> - "
1g" ⊟using Pyrrho.Common; 2 using Pyrrho.Level2;				- <b>-</b>	Search Solution Exp	olor 🔎 -
3 using Pyrrho.Level4; 4 using System:					Þ √C# Qu	eryClas 📥
5 using System.Net;					▷ ✓C# Rol	le.cs
6 ⊟// Pyrrho Database Engine by Malcolm Crowe at th 7 // (c) Malcolm Crowe, University of the West of	e University of the West Scotland 2004-2022	of Scotland			Þ ✓C# Tab	ole.cs
8 //					in the second se	ACColor
9 // This software is without support and no liabi 10 // You can view and test this code and use it s	lity for damage consequer ubject for any purpose.	ntial to use.			Þ ✓C# Tra	nsactio
11 // You may incorporate any part of this code in	other software if its or:	igin			Þ ✓ C# Tric	ager.cs
12 // and authorship is suitably acknowledged.					b ∠C# Use	PLCS
14 // this technology requires a license from the U	niversity of the West of	Scotland.				
15 Enamespace Pyrrho.Level3						ueics –
16 { 17   // <cumpanya< th=""><th></th><th></th><th></th><th></th><th>V VC+ Vie</th><th>w.cs</th></cumpanya<>					V VC+ Vie	w.cs
18 /// DBObjects with transaction uids are add	to the transaction's list	t of objects.		-	Level4	-
74 % 🔹 🧟 No issues found 🛛 😽 🔹 🔳		Ln: 1	Ch: 1 MIXED	CRLF	4	•
Ready		↑↓ 2/0 🔺		master 🔺	🚯 Shared 🔺	₽

Scroll down to line 175 at the start of the Transaction.Commit() method.

File         Edit         View         Git         Project         Build         Debug         Test         Analyze         Tools         Extensions         Search         P           Window         Help         Window         Help         Help	ivr — 🗆 🗙		
	🖻 Live Share 🖉		
Process: [0x3064] PyrrhoSvr.exe 🔹 🖬 Lifecycle Events 🔹 Thread:			
Transaction.cs 🕫 🗙 PyrrhoSvr 👻 🕏	Solution Explorer 📼 🕂 🗙		
@ PyrrhoSvr • 왕 Pyrrho.Level3.Transaction • 당 AutoCommit • ‡	ⓒ ⊝ 佘 ┛ ፬ - "		
172 df.Flush();	Search Solution Explor 🔎 🗸		
174 10 references	Þ ✓C# QueryClas ▲		
Bi 175 B internal override Database Commit(Context cx)	▷ ✓ C# Role.cs		
177 if (cx == null)	♦ ✓ C# Table.cs		
178 return notback(); 179 if (physicals == BTree <long, physical="">.Empty &amp;&amp;</long,>	Þ ✓C# TableColu		
180 (autoCommit    (cx.rdC.Count == θ & (cx.db as Transaction)?.etags == null)))	▷ ✓ C # Transactio		
181 return NoLLDack(); 182 // check for the case of an ad-hoc user that does not need to commit	♦ ✓ C # Trigger.cs		
if (physicals.Count == 1L && physicals.First().value() is PUser)	♦ ✓ C# User.cs		
184 return Rollback();	▷ ✓ C# Value.cs		
	▷ ✓ C# View.cs		
187 var ta = b.value();	b El Level4		
188 ta.defer = false;			
74% • 🎣 💟 No issues found 🛛 🏹 • 🔹 🕨 🕨 🕨 Ln: 1 Ch: 1 MIXED CRLF	▲ → →		
□ Ready 1↓ 2/0 ▲ 1⁄99+ 8º master ▲	🚯 Shared 🔺 💭 🔬		

Click the mouse in the left margin to set a break point at line 179 of the Transaction.cs file.

File Edit View Git Project Window Help	Build Debug Test Analyze Tr → ↓ ▶ Continue → 🎸 → │ 🖾 │ 👼 <sub>┯</sub> → 🕞 Lifecycle Events → Thread:	ools Extensions Search ♪	PyrrhoSva ₹	r — □ × 냥 Live Share &
Transaction.cs → × PyrrhoSvr Image: PyrrhoSvr · · · · · · · · · · · · · · · · · · ·	♣ Pyrrho.Level3.Transaction -		- ¢ - ÷	Solution Explorer 🔹 🕂 🗙
Bit 175       10 mintenness         176       internal override [         177       if (cx == null)         178       if (physicals =         180       (autoCommit         181       if (physicals =         182       // check for th         183       if (physicals =         184       if (physicals =         183       if (physicals =         184       if (physicals =         185       for (var b = co         186       ta.defar =         189       ta.defar =         199       }         191       j         74%       @ No issues found	<pre>batabase Commit(Context cx) batabase Commit(Context cx) back(); == BTree<long, physical=""> Empty &amp;&amp; == BTree<long, physical=""> Empty &amp;&amp; == BTree<long, physical=""> Empty &amp;&amp; == BTree<long, !="null;" <="" as="" b="b.Next" back();="" c.deferred.first();="" false;="" is;="" physicals="" pre="" tran="" value();=""></long,></long,></long,></long,></pre>	<pre>saction)?.etags == null))) eed to commit is PUser) ()) </pre> Ln: 1 Ch: 1 Mi	XED CRLF	Search Solution Explor



Then when we issue the commit command in the blue window,

## commit

Visual Studio stops at the breakpoint.

🗷 Command Prompt (Blue) - PyrrhoCmd t10 — 🗌 🗙	Command Prompt (Green) - PyrrhoCmd t10 - 🗆 🗙
<pre>1 records affected in t10 SQL&gt; insert into RDC values(52, 'Weeks in the year') 1 records affected in t10 SQL&gt; table RDC      A  B        42 LLife, the Universe   52 Weeks in the year       SQL&gt; begin transaction SQL-T&gt;clete from RDC where A=42 1 records in transaction t10 SQL-T&gt;commit</pre>	<pre>) Microsoft Corporation. All rights reserved. \Users\Malcolm&gt;cd \pyrrhodb70\pyrrho \PyrrhoDB70\Pyrrho2md t10 &gt; table RDC </pre>
File       Edit       View       Git       Project       Build       Debug       Test       Analyze         Window       Help         Image: Second Seco	Tools       Extensions       Search       P       PyrrhoSvr $ \times$ $\downarrow$ III       III       III       IIII       IIII       IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
Transaction.cs       +2       PyrrhoSvr         CE PyrrhoSvr       * % Pyrrho.Level3.Transaction         Image: Second Seco	Solution Explorer < 4 × Solution Explorer < 4 × Search Solution Explor  Search Solution Explor  Search Solution Explor  < C# QueryCla: > < C# Role.cs > < C# Role.cs > < C# TableColu > < C# User.cs > < C# User.cs > < C# User.cs > < C# View.cs > < C#
Ready	†↓ 2/0 ▲ 🖉 99+ 🖇 master ▲ 🚸 Shared ▲ 📮 🔬

Make the Debug>Windows>Watch>Watch 1 window visible,

File Edit View Git Project Build	Debu	ug Test Analyze	Tools	Extensions Search.		D PyrrhoSvr —	
		windows		,	:	Breakpoints	Ctrl+Alt+B
🖁 🕒 ♥ 🕑   🛍 ♥ 🞬 💾 🗒   ୬ ▪ ୯ ▪   🕨		Continue		F5	⊡.	Exception Settings	Ctrl+Alt+E
Process: [0x3064] PyrrhoSvr.exe -	1 10	Break All		Ctrl+Alt+Break		Output	
		Stop Debugging		Shift+F5	$\sim$	Show Diagnostic Tools	Ctrl+Alt+F2
Transaction.cs 🕁 🗙 PyrrhoSvr	X	Detach All			~	GDI Threads	
🖙 PyrrhoSvr 👻 😪 Pyrrh	1	Terminate All			~	or or micedas	
10 references Internal override Database C	1 15	Refinitiate All			Ē	Tasks	Ctrl+Shift+D, K
176 {	0	Restart		Ctrl+Shift+F5	(:::	Parallel Stacks	Ctrl+Shift+D, S
177 if (cx == null) 178 return Rollback():	Ű	Apply Code Changes		Alt+F10		Parallel Watch	•
179 if (physicals == BTree <l< p=""></l<>	· 🗠	Performance Profiler		Λl+⊥F2	_		
180 (autoCommit    (cx.r 181 return Rollback():	27	Relaunch Perforn	Watch 1	Ctrl+Alt+W, 1		Watch	•
182 // check for the case of	¢.,,	Attach to Process	Watch 2	Ctrl+Alt+W, 2	ø	Autos	Ctrl+Alt+V, A
183 if (physicals.Count == 1 184 return Rollback():	. ~		Watch 3	Ctrl+Alt+W, 3	<b>[</b> *]	Locals	Ctrl+Alt+V, L
185 = for (var b = cx.deferred	L _	Other Debug larg	Watch 4	Ctrl+ Alt+W 4	>	Immediate	Ctrl+Alt+I
186 $i$	¥ .	Step Into	Wateri 4				
188 ta.defer = false;	7	Step Over		F10	쎰	Live Visual Iree	
189 ta.db = this;	Ŷ	Sten Out		Shift+F11	Þ	Live Property Explorer	
191 }	•	step out		Shire 111		XAML Live Preview	
74 % 🔹 🏟 🥝 No issues found 🛛 😽	69	QuickWatch		Shift+F9	<b>{O</b> }	XAML Binding Failures	
💭 Ready		Toggle Breakpoint		F9		Call Stack	Ctrl+Alt+C

and Dock it below the text window. Use it to examine physicals and cx.rdC:

File       Edit       View       Git       Project         Window       Help	Build Debug Test Analyze	Tools Exter	nsions Sea 5   ↓ ↓ ↓	arch 🔎	PyrrhoS ↓ ↓ ↓ ↓	vr — É Live	□ Share	×
Process: [0x3064] PyrrhoSvr.exe	Lifecycle Events      Thread:	[0x23C0] T1		- P P	•¤‡		_	
Iransaction.cs     →     ×     Pyrmosvr       C# PyrrhoSvr     -	Ryrrho.Level3.Transaction	🛛 🗞 Commi	it(Context cx)	)	• ‡		arer 🔹	μ× • "
BT     175     Internal override D       176     internal override D       177     if (cx == null)       178     if (chysicals =       180     (autoComit       181     return Roll       74%     @ No issues found	atabase Commit(Context cx) back(); = BTree <long, physical="">.Empty &amp;&amp;    (cx.rdC.Count == 0 &amp;&amp; (cx.db as T back();   rightarrow 4</long,>	Transaction)?.et	ags == null) Ln: 179 CI	)) h: 13 MIXED	CRLF	Search Solution	n Explor # Query( # Role.cs # Table.c # TableC # Transac	Clas A s olu ctio
Watch 1       Search (Ctrl+E)       Name	- → Search Depth: 3 - I T T T the search Depth: 3 - I T T the search Depth (!0=Delete Record 112[23])} {}	2		Type Pyrrho.Commo Pyrrho.Commo	▼ ₽ ×	<ul> <li>↓ &lt; C:</li> <li>↓ &lt; C:</li></ul>	# Trigger # User.cs # Value.c # View.cs evel4	.cs :s
💭 Ready		ţ1	2/0 🔺 🕺	V 99+ So	master 🔺	🚸 Shared	I 🔺 🗘	1

<sup>[41 @ 19:33]</sup> 

Let's look at the physicals. **physicals** is the list of Physical records that the Transaction wishes to commit, and it's just the single Physical record to delete row 112 in the database which is "Life, the Universe".

[42 @ 19:50]

Also look at cx.rdS<sup>1</sup>, which is to do with the ReadConstraints for this particular Transaction. In this version of Pyrrho, it is currently empty because we have not performed any selects.

[43 @ 20:12]

Step Over a few times to get to line 198.

<sup>&</sup>lt;sup>1</sup> The illustration shows rdC instead. We will see in the next section that we really want rdS here.

File Edit View Git Project	Build Debug Test Analyze	Tools Extensions	Search 🔎	PyrrhoSvr	- 0	×
<ul> <li>● • ●   □ • ≅ □ □   ▷ • ○</li> <li>Process: [0x3064] PyrrhoSvr.exe</li> </ul>	<ul> <li>Continue • <i>ऍ</i> •   □   □</li> <li>Lifecycle Events • Thread: [0</li> </ul>	<sub>⊋</sub> है। ∎ 🗗 🚺 ↓ २ x23C0] T1	, אַן 1 יין אישן דיין	*** *** **	🖄 Live Share	: <i>R</i>
Transaction.cs 👳 🗙 PyrrhoSvr				<del>-</del> ≉ So	olution Explorer	
C# PyrrhoSvr	Ryrrho.Level3.Transaction	- Commit(Context	t cx)	• <del>‡</del> (	e o 🎧 🖓	<b>™</b> • • •
194 if (b. 195 cx	<pre>key() != name) .CheckRemote(b.kev(), b.value());</pre>	, ,		Ê. S	earch Solution Ex	plor 🔎 -
196 // Both rdr an	d wr access the database - not the tran	saction information			≬ ✓C# Qu	ieryClas 🔺
↓ 198 ② var rdr = new 198 ②	Reader(new Context(db), loadpos);				Þ ✓C# Ro	le.cs
200 wr.cx.nextHeap	= cx.nextHeap; // preserve Compiled ob	jects framing		<b>.</b>	▷ ✓ C # Tal	ble.cs
74 % 🔹 🧟 No issues found	<b>∛</b>	► Ln: 198	Ch: 13 MIXED	CRLF	V V C + Tra	nsactio
Watch 1				<b>-</b> ₽ ×	Þ ✓C# Tri	gger.cs
Search (Ctrl+E)	$\leftarrow \rightarrow$ Search Depth: 3 $\bullet$   TP $\frac{P}{ab}$				≬ ✓C# Us	er.cs
Name	Value		Туре	-	▷ ✓ C # Val	ue.cs
physicals	{(!0=Delete Record 112[23])}		Pyrrho.Commo	n.B	P ✓C# Vie	w.cs
Cx.rdC	0		Pyrrho.Commo	n.C	· · · ·	
					_	•
Ready		1↓ 2/0 ▲	🖉 99+ 💡	master 🔺	🚸 Shared 🔺	Д "

The validation step will use the up-to-date copy of the database, as it was left by the green window. We also open a Reader and a Writer: a Reader to look at this database, specifically at the records that have been committed since the start of our Transaction; and a Writer, where we will prepare the records that we (blue window) are going to add to the database if our validation succeeds.

These are not shareable and are subject to locking protocols. They also work on the same FileStream. (Transaction Commit() repeats the validation step after the locking the FilleStream.)

[44 @ 20:27]

Step Over to line203, just after a line saying "since=rdr.GetAll();" This gets the records that have been committed to the database since the start of our transaction.

File Edit View Git Project	Build Debug Test Analyze Tools	Extensions	Search 🔎	PyrrhoSvr	- D	$\times$
<ul> <li>€ • ○   10 • 2 • 10 • 10 • 10 • 10 • 10 • 10 •</li></ul>	<ul> <li>→ Continue - <i>(</i> →   □ →   □ → □</li> <li>→ □ Lifecycle Events - Thread: [0x23C0]</li> </ul>	"■ (5   ↓ ¥ m	? ↓ Ø		🖻 Live Share	R
Transaction.cs 👍 🗙 PyrrhoSvr				- ¢	Solution Explorer	- <del>-</del>
🖙 PyrrhoSvr 👻	🗞 Pyrrho.Level3.Transaction 🔹 😪 🕻	Commit(Context o	cx)	<b>-</b> ÷	◎ 🗇 🛺 🕻	
199 var wr = new Wr 200 wr.cx.nextHeap	<pre>iter(new Context(db), dbfiles[name]); = cx.nextHeap; // preserve Compiled objects file</pre>	raming			Search Solution Expl	or 🔎 -
201 var tb = physic 202 var since = rdr	<pre>:als.First(); // start of the work we want to o .GetAll(); will</pre>	ommit			▷ ✓ C# Que	ryClas ≜
204 E for (var pb = s	<pre>ince.First(); pb != null; pb = pb.Next())</pre>			Ţ	¢ ✓ C# Table	e.cs
74% 🚽 🔊 🖉 No issues found	∩	Ln: 203	Ch: 13 MIXED	CRLF	Þ ✓C# Table	eColu
Weards 1				- 1 -	▷ ✓ C # Trans	sactio
Search (Ctrl+E)	$\leftarrow$ $\rightarrow$ Search Depth: 3 - $\Box$ $\Box$			· + ^	Þ ✓C# Irigg Þ ✓C# User	er.cs
Name	Value		Type	-	≬ ✓ C# Valu	e.cs
▶ S physicals	{(!0=Delete Record 112[23])}		Pyrrho.Commo	n.B	≬ ✓C# View	.cs
▶ 🤝 cx.rdC	{}		Pyrrho.Commo	n.C	Level4	-
Add item to watch				$\sim$	<	•
💭 Ready		1↓ 2/0 🔺	1 99+ ge i	master 🔺	🚸 Shared 🔺	Д

Use the Watch window to examine **since**.

File       Edit       View       Git       Project         Window       Help         Image: State of the state	t Build Debug Test Analyze २ -   ► Continue - 🎸 -   🗊   👼 - 🗊 Lifecycle Events - Thread: [	Tool = 0x23C	; Extensions III ■ (5   ↓ 1 0] T1	Search ♀ ↓ ? ↑   ∦ ↓ ■	PyrrhoSvr ∓ ∓ ∓ p™ ⋈ ∵	r — B∂Liv	🗆 re Share	×
Transaction.cs → × PyrrhoSvr Image: PyrrhoSvr	• Ryrrho.Level3.Transaction	• 6	Commit(Contex	t cx)	- ☆ - ÷	Solution Exp	olorer 🔻	
<pre>199 var wr = new Writer(new Context(db), dbfiles[name]); 200 wr.cx.nextHeap = cx.nextHeap; // preserve Compiled objects framing 201 var tb = physicals.First(); // start of the work we want to commit 202 Physical ph = null; 203 Physical ph = null; 204 for (var pb = since.First(); pb != null; pb = pb.Next()) 205 { c t = ct value(); 206 }</pre>								yClas → cs ccolu
Watch 1 Search (Ctrl+E)	$\leftarrow \rightarrow$ Search Depth: 3 • 7 $\square$		Copy Paste		C	itrl+C itrl+V	C# Trans C# Trigg C# User.	actio er.cs cs
Name	Value {(!0=Delete Record 112[23])} {) {/(0=DTransaction for 1 Role=-5021]rec	62 62	Copy Value Add Watch	ch			C# Value C# View. Level4	.cs
Ready		čə	Delete Watch				ed 🔺	Д,

[45 @ 21:23]

Right-click and copy the value into a Notepad. Add a little extra white space to make it more readable.

t View Git Projec Help ア・ピ 日 日 日 / ク・	*Untitled - Notepad File Edit View	-	(
064] PyrrhoSvr.exe var wr = new wr.cx.nextHea var tb = physic var since = r Physical ph = for (var pb = {	{(0=PTransaction for 1 Role=-502 User=-501 Time=25, 1=Update 112[23]: 71=The answer to the ultimate o	/10/2022 08:20:57, question Prev:112)	}
	Ln 2, Col 3 100% Windows (CR	LF) UTF-8	
<b>₽</b> - <	- $ ightarrow$ Search Depth: 3 🔹   TP 🖶		
	Value	Туре	h.
s	{(!0=Delete Record 112[23])}	Pyrrho.Common.B	
	8	Pyrrho.Common.C	
	{(0=PTransaction for 1 Role=-502 User=-501 Time=25/10/2022 0	Pyrrho.Common.B	•

We can see we have got the transaction marker and the update that the green window has made.

We have just (at line 201) set tb = physicals.First(), a bookmark for the first physical item that our transaction is wanting to commit. We will check our physicals with anything that has happened since the start of our transaction.

Set a breakpoint at line 237.

File Edit Window H	View Git Project Help → 💕 💾 🗐   ∽ → Ϙ 41 PvrrhoSvr.exe	Build Debug	Test Analyze	Tools Ext	tensions び   ↓ ⊃	Search	   ∦ _ - ⊫ ⊪	PyrrhoSv = = = xx = =	r – ⊮≧L	□ ive Share	× R
Transaction.cs -=	× PyrrhoSvr	<sup>6</sup> ⊗ Pyrrho.Level3.Tr	ansaction	▼ 🗞 Com	mit(Context	t cx)		- ¢ - ÷	Solution E	cplorer	- ₽ ×
232 233 234 235 236 237 238 238 74 %	<pre>} */ for (var b {     var p =     var ce     if (ce);     No issues found</pre>	<pre>= tb; b != null; b b.value(); = ph.Conflicts(rdr. =null) </pre>	= b.Next()) context.db, cx, p,	pt);	Ln: 201	Ch: 19	MIXED	CRLF	Search Sol	vtion Exp ✓ C # Qu ✓ C # Rol ✓ C # Tab ✓ C # Tab	eryClas e.cs le.cs leColu
Watch 1 Search (Ctrl+E) Name	> • (ع	<ul> <li>→ Search Depth</li> <li>Value</li> <li>{(!0=Delete Record</li> </ul>	n: <u>3 - 7</u> - 7	2		Type	.Commo	• 4 ×		✓C# Irai ✓C# Trig ✓C# Use ✓C# Vali ✓C# Vie	nsactio jger.cs er.cs ue.cs w.cs
<ul> <li>So physicals</li> <li>So cx.rdS</li> <li>So since</li> <li>Ready</li> </ul>		{} {(0=PTransaction f	or 1 Role=-502 Use	r=-501 Time=2	25/10/2022 ( 1↓ 2 / 0 ▲	Pyrrho D Pyrrho Ø 994	common Common Common	n.C n.B 👻	▶	Level4	. , ·

Click Continue

N	File Exter	Edit sions	View Window	Git v H	Project elp	Build	Debug	Test	Analyze	Tools	Search	٩	PyrrhoS	ivr —		×
Sec.	- 0	18	- 🝰 💾	<b>1</b>	9-6	-	Continue	•		• • •	) → :	? :	<b>•</b> • •	🖻 Live	Share	ጽ
Trans	action	.cs 💠	× Pyrrl	noSvr	C	ontinue							÷ ¢	Solution Explo	orer	• 4 ×
C# D	urrhoS	ur		1 1 D	wirtho Leve	13 Tranca	ction		• Ø.,	Commit/(	Context cv)		* <del>*</del>	0 0 4	THE T	

# [47 @ 21:41]

The first time we hit this particular line, ph is the transaction record, as we can see in the Watch window,

74 % 🔹 🎡	No issues found		4		•	Ln: 237	Ch: 21	MIXED	CRLF	↓ ✓ C# Transactio
Watch 1										♦ ✓ C# Trigger.cs
Search (Ctrl+E)	ج - <b>م</b>	- ightarrow Search I	Depth: 3	- TP 🖫						♦ ✓ C# User.cs
Name		Value					Туре		-	♦ ✓ C# Value.cs
▶   cx.rdS		{}					Pyrrho.	Commo	n.C 🔳	▷ ✓ C# View.cs
Image: Since Since		{(0=PTransact	tion for 1 Ro	le=-502 User=-50	01 Time=25	/10/2022 0	Pyrrho.	Commo	n.B	D Level4
👂 🤣 ph		{PTransaction	for 1 Role=	-502 User=-501 T	ime=25/10	/2022 09:1	B Pyrrho.	Level2.P	hysi 👻	
💭 Ready					ţ1	2/0 🔺	🖉 99+	۶e ا	master 🔺	🚸 Shared 🔺 🚨 🔮

which is not very interesting.

**Click Continue** 

File Edit View Git Project Window Help	Build Debug Test Analyze	Tools Extensions	Search 🔎	PyrrhoSvr	— C	
ⓒ ▼ ⊙            □ ▼ ≅ □         □ > ▼            Process:         [0x628C] PyrrhoSvr.exe	<ul> <li>► Continue ▼ <i>df</i> ▼   □□   □□</li> <li>■ Lifecycle Events ▼ Thread:</li> </ul>	] <sub>→</sub> 🔋 🔳 🔳 🕑   ↓ 🚦 [0x6F5C] T1	: ? 1 Ø . • ₪ ₪		🖻 Live Sha	re 🕅
Transaction.cs → × PyrrhoSvr	As Pyrrho Level3 Transaction	• Commit/Context	(A)	- ¢	Solution Explorer	- ∓ ∓ ×
234     for (var b =       235     {       236     var p =       237     var p =       238     if (cell       239     cx.1       74%     Image: Construction of the second of the seco	<pre>crymnolecteds.mansdelwin = tb; b != null; b = b.Next()) b.value(); = ph.Conflicts(rdr.context.db, cx, p, null) wconflicts++; % * </pre>	<pre>pt);</pre>	Ch: 21 MIXED	CRLF	() () () () () () () () () () () () () (	QueryClas Cole.cs Table.cs TableColu
Watch 1           Search (Ctrl+E)         ♪ ▼ ●           Name         ▶ ⊗ cx.rdS           ▶ ⊗ since         ▶ ⊗ ph	- → Search Depth: 3 → T中 Tage Value { { (0=PTransaction for 1 Role=-502 Use { Update 112[23]: 71=The answer to th }	9 r=-501 Time=25/10/2022 ( e ultimate question Prev:1	Type Pyrrho.Commo Pyrrho.Commo Pyrrho.Level2.P	▼	▷ - C # T ▷ - C # U ▷ - C # U ▷ - C # V ▷	rigger.cs Jser.cs /alue.cs /iew.cs !4
Ready		↑↓ 2/0 🔺		master 🔺	🚯 Shared 🔺	, Q

The second time, ph is the Update from the green window, and we Step into the call to Conflicts:

File Edit View Git Project Window Help	Build Debug Test Analyze Tools	Extensions Sear	rch 👂 🖡	PyrrhoSvr		1 ×
	🔹 🕨 Kontinue 🕶 🎸 🕶 🖾 📮 🕅	■ U   ↓ ‡ ?	1   # _ 8 -	• 3 •• ≠ 3 ∓	🖻 Live Shar	e 🕅
Process: [0x628C] PyrrhoSvr.exe	Lifecycle Events - Thread: [0x6F5C]	1	• 🏴 P <sup>®</sup> ×	⊲ ‡		
Transaction.cs PyrrhoSvr		L	Update.cs 🗯 🗙	👻 🏟 Sol	ution Explorer	
E PyrrhoSvr -	🛠 Pyrrho.Level2.Update 🔹 😭 C	onflicts(Database db	, Context cx, Phy	/ <b>-</b> ‡ ⊛	) 🖓 🖓	<b>™</b> • ⊡
79 base.Deserialis	e(rdr);			📩 Sea	arch Solution Ex	cplor 🔎 -
25 meterances       25 meterances       public override DBE       81       93       83       94       6       90       90       90       90       90       91       91       92       93       94       95       96       97       97	xception Conflicts(Database db, Context cx, Ph e) ron:	ysical that, PTransa	action ct)		♦ ✓ C# Q ♦ ✓ C# Ro ♦ ✓ C# Ta ♦ ✓ C# Ta	ueryClas A ble.cs ble.cs bleColu
Wetch 1		P En. 02 Ch			♦ ✓C# Tra	ansactio
Search (Ctrl+E)	$\dot{\leftarrow} \rightarrow$ Search Depth: 3 - $\dot{\Box}$			Ť ~		ser.cs
Name	Value	Ţ	ype .		Þ ✓ C # Va	ew.cs
<ul> <li>▷ ∅ cx.rdS</li> <li>▷ ∅ since</li> <li>▷ ∅ ph</li> </ul>	{} {(0=PTransaction for 1 Role=-502 User=-501 Tin {Update 112[23]: 71= The answer to the ultimate	ne=25/10/202 ひ P question Pre ひ P	yrrho.Common.G yrrho.Common.E yrrho.Level2.Phy	C B ▼ 41	Level	4
💭 Ready		†↓ 2/0 <b>-</b> 🖉	²99+ }₽ ma	aster 🔺	🚸 Shared 🔺	Д,



Click StepOver: stop at line 99, where our Delete is tested against their update:

File Edit Window H	View Git Project Build Debug Test Analyze Ielp	Tools Extensions	Search 🔎	PyrrhoSv	n — 🗆	×
8 € • ⊖   10 •	- 🖼 🖹 🗿   🤊 - 🖓 -   🕨 Continue - 🝏 -   🛼   👼	i 📲 💷 🖉   🗸 🕴		÷ ÷ ÷	🖄 Live Share	R
Process: [0x6280	] PyrrhoSvr.exe   E Lifecycle Events   Thread:	(0x6F5C] T1	- 🏴 p <sup>p</sup>	∞ ‡		
Transaction.cs	PyrrhoSvr		Update.cs 🐞	× - *	Solution Explorer	
E# PyrrhoSvr	← 🍫 Pyrrho. evel2.Update	- 😚 Conflicts(Databa	se db, Context cx, P	hy <del>•</del> ‡	🕞 🗇 🎧 🖉 🗋	© • "
94 95	} case Type.Delete:			<b>^</b>	Search Solution Exp	olor 🔎 -
96	case Type.Deletel:			<u> </u>	Þ ✓C# Qu	eryClas 🔺
98	<pre>var de = (Delete)that;</pre>				Þ ✓C# Rol	e.cs
P 99 ♥ 100	ret b 🖉 de (Delete Record 112[2]	1] - at. ct):		- <b>-</b>	≬ ✓ C# Tab	le.cs
74%	No issues found	In: 99	Ch: 25 MIXED	CRIE	≬ ✓ C# Tab	leColu
			CHI LO HIMLED	Citter	≬ ✓C# Tra	nsactio
Watch 1				- 4 ×	Þ ✓C# Trig	ger.cs
Search (Ctrl+E)	ho $ ho$ $ ho$ $ ho$ $ ho$ Search Depth: 3 $ ho$ $ $ $ ho$ $ ho$ $ ho$	3			≬ ✓C# Use	er.cs
Name	Value		Type		▷ ✔C# Val	ue.cs

and since these both are for the same defining position 112, we will raise an exception.

File       Edit       View       Git       Project       Build       Debug       Test       Analyze       Tools       Extensions       Search         Window       Help       Help		vr — 🗆	× = &
Transaction.cs     PyrrhoSvr     Upd       Image: PyrrhoSvr     Image: PyrrhoLevel2.Update     Image: PyrrhoLevel2.Update     Image: PyrrhoLevel2.Update	late.cs 🗯 🗙 🝷 🌣 ontext cx, Phy 🚽 ≑	Solution Explorer	- ∓ × ™ - "
94       }         95       case Type.Delete:         96       case Type.Delete1:         97       {         98       if (de.delpos == defpos)         return new DBException("#0029", defpos, that, ct);         74 %       ✓         74 %       ✓	MIXED CRLF	Search Solution Ex > < C# Qu > < C# Qu > < C# Rc > < C# Ta > < C# Ta > < C# Ta	plor P - ueryClas - ile.cs ble.cs bleColu ansactio
Watch 1         Search (Ctrl+E) $\wp \bullet \leftarrow \to$ Search Depth:         3       • $\neg \square$	<del>-</del> ∓ ×	Þ ✔C#Tri Þ ✔C#Us	gger.cs er.cs
Name     Value     Type       > ()     ()     ()       > ()     ()     ()       > ()     ()     ()       > ()     ()     ()       > ()     ()     ()       > ()     ()     ()       > ()     ()     ()       > ()     ()     ()       > ()     ()     ()       > ()     ()     ()       > ()     ()     ()       > ()     ()     ()       > ()     ()     ()       > ()     ()     ()       > ()     ()     ()	no.Common.C no.Common.B no.Level2.Physi	<ul> <li>↓ ~ C # Va</li> <li>↓ ~ C # Via</li> <li>↓ Level4</li> <li>↓ ~ -</li> </ul>	lue.cs
□ Ready 1↓ 2/0 ▲ 2/99	9+ 🖓 master 🔺	🚸 Shared 🔺	Д "



Click Continue twice, and we get the resulting message in the blue window:



We see that we get a complaint back in the blue window that record 112 has just been updated. The transaction has been rolled back, as we see from the prompt.

That completes the first experiment that we want to do in this demonstration.

[53 @ 23:01]

# Part 3: A Read-Write Transaction

Stop the server, stop the programs in both command windows with control-C, delete the database t10, restart the server, and recreate the database as in part 1 above, so that we have the same situation as slide 35.

## [54 @ 23:18]

Command Prompt (Blue) - pyrrhocmd t10 —	Command Prompt (Green) - pyrrhocmd t10 - C
SQL> ^C C:\PyrrhoDB70\Pyrrhozpyrrhocmd t10 SQL> create table RDC(A int primary key,8 char) SQL> insert into RDC values(42, 'Life, the Universe') 1 records affected in t10 SQL> insert into RDC values(52, 'Weeks in the year') 1 records affected in t10 SQL> table RDC 	

This time, when we start an explicit transaction in the blue window, instead of deleting something, we are going to select a single row from the RDC table, and we stick with A=42 again.

## begin transaction

# select \* from RDC where A=42

Command Prompt (Blue) - pyrrhocmd t10	_	×	Prompt (Green) - pyrrhocmd t10 - 🗆 🗙
SQL> table RDC                     A  B                     42 Life, the Universe           52 Weeks in the year                      SQL> begin transaction         SQL-T>select * from RDC where A=42                     A  B                     42 Life, the Universe                      30L-T>         SQL-T>			 RDC set B='The answer to the ultimate question' where A=42 ffected in t10 70\Pyrrho>pyrrhocmd t10 RDC 

[55 @ 23:33]

Just as before, the green window makes an update to the same row,

## update RDC set B='The product of 6 and 9' where A=42

which is auto-committed. For the reasons explained earlier, we expect that the blue window will now be unable to commit.

Command Prompt (Blue) - pyrrhocmd t10 -	Command Prompt (Green) - pyrrhocmd t10 - C
SQL> table RDC                     A  B                     42 Life, the Universe           52 Weeks in the year                               SQL> begin transaction         SQL-T>select * from RDC where A=42                                 A  B           A  B                       42 Life, the Universe                                   SQL-T>	<pre>1 records affected in t10 SQL&gt; ^C C:\PyrrhoDB70\Pyrrho&gt;pyrrhocmd t10 SQL&gt; table RDC       A   B         42 Life, the Universe    52 Weeks in the year     </pre>



Add or restore the break point in the Transaction.Commit() method.

File Edit View Git Project Window Help © • • • • • • • • • • • • • • • • • • •	Build Debug Test Analyze →   ▶ Continue → 🎸 →   📪   🛱 → 🔀 Lifecycle Events → Thread:	Tools Extensions <sub>→</sub> III ■ (J   ↓	Search ♀	PyrrhoSv	r — [ 순 Live Shar	] × re ₽
Transaction.cs     ⇒     ×     PyrrhoSvr       E™ PyrrhoSvr     -	Spyrrho.Level3.Transaction	- 玲 Commit(Contex	Update.cs 🐁 t cx)	☆ <del>-</del> × +	Solution Explorer	•
176     if (cx == null)       177     if (physicals =       180     if (utoComit       181     return Roll       182     if (physicals =       183     if (physicals =       183     if (physicals =       74%     If (physicals =	back(); = BTree <long, physical="">.Empty &amp;&amp;    (cx.rdC.Count == 0 &amp;&amp; (cx.db as Tr back(); e case of an ad-hoc user that does not ount == 1L &amp;&amp; physicals.First().value(   * + 4</long,>	ansaction)?.etags == n need to commit ) is PUser) ▶ Ln: 179	Ch: 13 MIXED	CRLF	Search Solution E	xplor P - QueryClas - ole.cs able.cs ableColu
Watch 1				• ¶ ×	¢ √C# Tr	rigger.cs
Search (Ctrl+E) Name ▷	← → Search Depth: 3 ▼ Value 0 null null		Type Pyrrho.Commo Pyrrho.Commo Pyrrho.Level2.P	n.C n.B hysi 🗸	▷ ✓ C# U ▷ ✓ C# V ▷ ✓ C# V ▷ ✓ C# V ▷ Level ↓	ser.cs alue.cs iew.cs 14
💭 Ready		↑↓ 2/0 🔺		master 🔺	🚯 Shared 🔺	Д,

[57 @ 23:25]

and in the blue window,

#### commit

On the commit command, we hit the break point.

A IB       Ffected in t19         70L Psychology Psychology 119       70L Psychology Psychology 119         70L Psychology 119       70L Psychology 119         70L Psycho	Command Prompt (Blue) - pyrrhocmd t1	10 — 🗆 X	Prompt (Green) - pyrrhoc	md t10	$ \Box$ $\times$
File       Edit       View       Git       Project       Build       Debug       Test       Analyze       Tools       Extensions       Search       PyrrhoSvr       Image: Search       Search Solution Explorer       Pyrrh	A  B		ffected in t10 70\Pyrrho>pyrrhocmd RDC   he Universe  n the year   	t10 Juct of 6 and 9' whe	ere A=42
Transaction.cs       ⇒       PyrthoSvr       Update.cs       ⇒       Solution Explorer        >       >         IT76       if (cx == null)       ·	File       Edit       View       Git       Project         Window       Help         Image: State of the state	Build     Debug     Test     Analyze       ▼     ►     Continue ▼	Tools Extensions 5€ ↓ 11 ■ (5   ↓ ↓ x339C] T1	earch ♀ Pyrrhos ? ↓   Ø ↓ "↓ "↓ ↓ ■ № ⋈ ↓	Svr — 🗆 🗙
Watch 1         ← 年 ×         ↓ ~ C = MinJacto           Search (Ctrl+E)         ♪ ~ ← → Search Depth: 3 • <sup>†</sup> □ <sup>n</sup> <sub>BD</sub> ↓ ~ C = Triger, cs         ↓ ~ C = Triger, cs           Name         Value         Type         ↓ ~ C = Value, cs         ↓ ~ C = Value, cs           ▷          {}         ↓ prino.Common.B         ↓ ~ C = Value, cs           ▷          ((23=(112=True)))         Pyrrho.Common.B         ↓ < Level4	Transaction.cs     >>     >>     PyrrhoSvr       Image: Image of the state of the	<pre>% Pyrrho.Level3.Transaction ack(); BTree<long, physical="">.Empty &amp;&amp;    (cx.rdC.Count == 0 &amp;&amp; (cx.db as Tr ack(); case of an ad-hoc user that does not unt == 11 &amp;&amp; physicals.First().value(   ※ &lt; </long,></pre>	<pre> • Commit(Context cx ansaction)?.etags == null) need to commit ) is PUser)</pre>	Update.cs 1 × ♥ ↔ () ♥ + ()	Solution Explorer + + × Search Solution Explor
	Watch 1       Search (Ctrl+E)       Name       ▷ ∯ physicals       ▷ ☆ since	- → Search Depth: 3 ・ <sup>1</sup>	11 210		<pre>&gt; C# Trigger.cs &gt; C# User.cs &gt; C# User.cs &gt; C# Value.cs &gt; C# Value.cs &gt; CE Value.cs &gt; CE Value.cs</pre>



In the Watch window, we can see that this time the physicals list for the blue window is empty, but it has a readConstraint in rdS, for table 23 and the single record 112 that it has read. (We haven't fetched

**since** yet.) If you also look at cx.rdC, you will see that it tells us that both columns 31 and 71 have been read.

File       Edit       View       Git       Project         Window       Help         Image: State of the state	Build Debug Test Analyze Tools	Extensions <u>Search</u>	PyrrhoSv <sup>*</sup> ∓ <sup>*</sup> ∓ <sup>®</sup> ∞ <sup>*</sup> ∓	rr ー ロ × Ist Live Share 尿
Transaction.cs         ⇒         PyrrhoSvr           Image: Second	Byrrho.Level3.Transaction <ul> <li></li></ul>	Update.cs ,Commit(Context cx) ion)?.etags == null))) to commit User)	₩ X ▼ \$	Solution Explorer  Search Solution Explor  Search Solution Explored  Search Solu
Watch 1 Search (Ctrl+E)	← → Search Depth: 3 • 1 7 ₽ ₽ Value null null {(31= True, 71= True)}	Type Pyrrho.Con Pyrrho.Leve Pyrrho.Con ↑↓ 2/0 ▲ ♀ 99+	₽ ×       nmon.B       el2.Physi       nmon.C       8 <sup>9</sup> master ▲	↓ < C# Trigger.cs ↓ < C# Trigger.cs ↓ < C# User.cs ↓ < C# Value.cs ↓ < C# Value.cs ↓ < C# View.cs ↓



Since rdS is not empty, let's put a break point at line 212:

File Edit View Git Project	Build Debug Test Analyze Tools Extension	ons Search <b>P</b> PyrrhoSvr - C X
	🔹 🕨 🕨 Continue 🕶 🎸 🕶 📴 👘 🗮 🗸 🚺 🔳 🕚	🗸 🌵 📬 🗘 🖉 📮 🚆 🙄 🖄 Live Share 🛛 🖗
Process: [0x2220] PyrrhoSvr.exe	Lifecycle Events + Thread: [0x339C] T1	▼ P P P
Transaction.cs 👍 🗙 PyrrhoSvr		Update.cs 🗯 🗙 🔻 🏟 Solution Explorer 📼 🕂 🗙
C# PyrrhoSvr	Pyrrho.Level3.Transaction     → Commit(	Context cx) 🔹 🗧 🕞 🖓 🚚 🔞 🗸 ''
209 210 = if (cx.rdS[	phTable] is CTree <long, bool=""> ct)</long,>	Search Solution Explor 🔎 🗸
211 ■ 212 = if (ct.	Contains(-1L))	▷ ✓ C# QueryClas ▲
213 214 cx.:	rconflicts++;	↓ ✓ C# Role.cs
215 thr	<pre>ow new DBException("4008", phTable);</pre>	► ► ► C# TableColu
74 % 🔹 🧟 No issues found	🛛 😽 🕶 🔹 🕨 👘	n: 179 Ch: 13 MIXED CRLF
Watch 1		→ ┦ × D → C# Trigger.cs
Search (Ctrl+E)	$ \rightarrow$ Search Depth: 3 $ \square$	▷ ✓ C# User.cs
Name	Value	Type ▲ ▷ ✓ C# Value.cs
🤣 ph	null	Pyrrho.Level2.Physi
▶ 🤣 cx.rdC	{(31=True,71=True)}	Pyrrho.Common.C
Add item to watch		
Ready		2/0 🔺 🖉 99+ 🖇 master 🔺 🚸 Shared 🔺 🚨 💡

and click Continue to reach this point:

File Edit View Git Project Window Help	Build Debug Test Analyze Tools	Extensions Search.	. P PyrrhoS	vr — 🗆	$\times$
୍ଥି 🕒 • ଡ   ଅ • 🖬 🖪 🗐   ୨ • ୯	-   🕨 Continue - 🎸 -   🎼   🚮 🚽 💷	■ (5   ↓ ‡ ? 1	∦; <sub>∓</sub> ° <u>∓</u> ° <u>∓</u> ° <u>∓</u> °	🖻 Live Share	R
Process: [0x2220] PyrrhoSvr.exe	Lifecycle Events      Thread: [0x339C] T1		• 🏴 🖻 🖂 🍹		
Transaction.cs 👍 🗙 PyrrhoSvr		Upd	ate.cs 🛎 🗙 👻 🌣	Solution Explorer	
🖙 PyrrhoSvr 🗸	🗞 Pyrrho.Level3.Transaction 🔹 😪 Co	ommit(Context cx)	<b>-</b> ÷	6 🕘 🎧 🎜	• •
209 pt = (PT 210 ⊟ if (cx.rdS[p	<pre>iransaction)ph; hTable] is CTree<long, bool=""> ct)</long,></pre>		· ·	Search Solution Exp	olor 🔑 -
211 t 212	Contains(-1L))			Þ ✓C# Qu	eryClas 🔺
213				Þ ✓C# Rol	e.cs
215 thro	w new DBException("4008", phTable);		<b>T</b>	Þ ✓C# Tab	le.cs
74 % 🗸 🌒 🖉 No issues found	∛ - ∢	Ln: 212 Ch: 21	MIXED CRLF	Þ ✓ C # Tab	leColu
W-+			~ 1 V	P ✓C# Irai	nsactio
Watch I			* * ~	P V C # Ing	iger.cs
Search (Ctrl+E)	- → Search Depth: 3 💽   甲 謳			P V C + Use	erics
Name	Value	Туре	<b>^</b>	P ✓ C# Van	ue.cs =
▶ 🤣 ph	{Update 112[23]: 71=The product of 6 and 9 Prev	:112} Pyrrh	no.Level2.Physi	P VC# Vie	w.cs
▶ 🥪 cx.rdC	{(31=True, 71=True)}	Pyrrh	no.Common.C	P Level4	
Add item to watch			Ψ.	•	- F
Ready		†↓ 2/0 ▲ 🖉 99	)+ ♀ master ▲	🚯 Shared 🔺	Δ

We see the readConstraint for our transaction is for a specific row 112. Step over to line 217,

File Edit View Git Project	Build Debug Test Analyze Tools Extensions	Search 🔎 PyrrhoS	vr — 🗆 🗙
Window Help			
🖁 🕒 • 🐵   🛅 • 💕 💾 🗐   ७ • ९	🕞 🕨 Continue 🕶 🍏 🖌 📖 🗛 🗸 💷 🖿 🔰 🗸 🐇	· ~ ↑   Ø ₊0 ‡0 ‡	🖻 Live Share 🛛 🖗
Process: [8736] PyrrhoSvr.exe	Lifecycle Events      Thread: [13212] T1	• 🖻 🖻 🖂 🚆	
Transaction.cs 👍 🗙 PyrrhoSvr		Update.cs 🛎 🗙 👻 🏚	Solution Explorer $~$ $=$ $~$ $+$ $\times$
🖙 PyrrhoSvr 🗸 🗸	Apprrho.Level3.Transaction	cx) - +	ⓒ ∋ 佘 ਯ 'o - "
212 = if (ct.)	Contains(-1L))	<u>^</u>	Search Solution Explor 🔎 -
214 cx.1 215 thr	<pre>rconflicts++; ow new DBException("4008", phTable);</pre>		Þ ✓C# QueryClas ▲
216			C# Role.cs
217 = F 1+ (ct.)	ontains(ph, Affects) & ph. Conflicts(cx, rdc, bt) is exception b of ph. {Update 112[23]: 71=The product of 6 and 112[23]: 71=The product of 70[20]: 71=The product of 70[20]: 71[20]: 71[20]: 71[20	e) nd 9 Prev:112} -=	♦ 🗸 C# Table.cs
219 cx.1	conflicts++,	· · · · · · · · · · · · · · · · · · ·	Þ ✓C# TableColu
74 % 👻 🤍 💟 No issues found	😽 🕈 🔹 👘 En: 217	Ch: 21 MIXED CRLF	◊ ✓ C# Transactio
Watch 1			♦ ✓ C# Trigger.cs
Search (Ctrl+E)	$ \rightarrow$ Search Depth: 3 $ T = \frac{1}{2}$		↓ ✓ C# User.cs
Name	Value	Type 🔺	↓ ✓ C# Value.cs
▶ 🔗 ph	{Update 112[23]: 71=The product of 6 and 9 Prev:112}	Pyrrho.Level2.Physi	C# View.cs
▶ 🔿 cx.rdC	{(31= True, 71= True)}	Pyrrho.Common.C	👂 🛅 Level4 🚽
Add item to watch		· · · · · · · · · · · · · · · · · · ·	<pre> 4 </pre>
Ready	↑↓ 2/0 🔺	🖉 99+ 💡 master ▲	🚸 Shared 🔺 🚨 👘

where we see that the green window's update is for the same row. Step into the Conflicts call, which receives the list of columns we have read:

File Edit View Git Project Window Help	Build Debug Test Analyze	Tools Extensions	Search 🔎	PyrrhoSvr	-		×
ैं <b>© •</b> ⊝   ीip • <b>≅ 🖪 m</b>   ५ • <	🛛 🗸 🕨 Continue 🕶 🎸 🕇 🐻 🖥	∃ = 🕺 💷 🖉   ↓	* ? î 🖉 🚽	8 * 8 * 8 ∓ 8 ∓	🖻 Live S	hare	R
Process: [8736] PyrrhoSvr.exe	Lifecycle Events      Thread:	[13212] T1	- P p				
Transaction.cs PyrrhoSvr			Update.cs 🗯	<mark>×                                    </mark>	olution Explor	er 🔻	
Œ PyrrhoSvr -	✤ Pyrrho.Level2.Update	<ul> <li>Conflicts(CTree</li> </ul>	<long, bool=""> t, PTra</long,>	nsa 🔹 🛨 🏾 🤅	0 0 h 🗸	1 0	• "
Bit     161     Image: Second	<pre>ixception Conflicts(CTree<long, bool=""> First(); b != null; b = b.Next()) Contains(b.key())) new DBException("40006",b.key(),this</long,></pre>	t,PTransaction ct)	,71=True)} -□	CRLF	earch Solution	Query Query Role.cs Table.c TableC Transac	Clas A s colu ctio
Watch 1				<b>-</b> ₽ ×	Þ √C#	Trigger	.cs
Search (Ctrl+E)	$\leftarrow \rightarrow$ Search Depth: 3 - $\Box$	Ъ			Þ √C#	User.cs	5
Name	Value	_	Type		Þ √C#	Value.c	:s
▶ 🔗 ph	{Update 112[23]: 71=The product of	6 and 9 Prev:112}	Pyrrho.Level2.	Physi	Þ ✓C#	View.cs	s
▶ 🥪 cx.rdC	{(31=True,71=True)}		Pyrrho.Comm	on.C	D 🗖 Le	vel4	-
Add item to watch				<b>T</b>		- C	•
Ready		1↓ 2/0 4	<b>↓</b> 99+ }₽	master 🔺	🚸 Shared	• C	1

## [64 @ 25:28]

and the exception is raised, terminating the blue transaction (click Continue twice).

Command Prompt (Blue) - pyrrhocmd t10	—	$\times$	Prompt (Green) - pyrrhocmd t10 —	$\times$
A  B			ffected in t10	
42 Life, the Universe 52 Weeks in the year 			70\Pyrrho>pyrrhocmd t10 RDC	
SQL> begin transaction SQL-T>select * from RDC where A=42 				
A  B         42 Life, the Universe     SQL-T>commit Transaction conflict: column 71			he Universe  n the year   	
sqL>				

This completes the demostration of a read-write conflict.

[Ends]

As an extra (optional) experiment, we can show that read-write conflicts operate at the row level by using different rows. We can continue in the current state, or repeat the setting up stage. In the blue window:

begin transaction

select \* from RDC where A=52

We can check that selects and updates even for the same row will not conflict if the columns affected are different.

These tests are left for you as an exercise.