Recovery

1) Undo
2) Redo

1) Scan log backwards
2) Winners = C + A
3) Losers:
→ 4) Redo C winners + undo losers.
Isolation

$T_1$

1) read $x$
2) write $x$
3) write $y$
4) write $y$

$T_2$

$r_1(x)$ $w_2(x)$ $w_1(y)$ $w_2(y)$

$r_1(x)$ $w_2(x)$ $w_2(y)$ $w_1(y)$

$r(z)$ $w(z)$

$w(z)$ $r(z)$

$w(z)$ $w(z)$
Serializability:

Trace’s conflict arrow in same order as some serial order of actions
Action Graph

<table>
<thead>
<tr>
<th></th>
<th>$T_1$</th>
<th>$T_2$</th>
<th>$T_3$</th>
<th>$T_4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$r_1$</td>
<td>$x$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>$w_2$</td>
<td>$x$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>$r_3$</td>
<td>$y$</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td>$r_4$</td>
</tr>
<tr>
<td>5</td>
<td>$w_1$</td>
<td>$y$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>$w_2$</td>
<td>$y$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td>$w_3$</td>
<td>$z$</td>
</tr>
</tbody>
</table>
If Action Graph is acyclic
\[\iff\text{trace is serializable}\]
\[\Rightarrow:\text{Topo. sort}\]
Locks:

acq (lock of x)
rel ("")

1
\[
\begin{align*}
acq & \ l_x \\
r_1(x) & \\
rel & \ l_x \\
acq & \ l_y \\
w_1(y) & \\
rel & \ l_y
\end{align*}
\]

2
\[
\begin{align*}
acq & \ l_x \\
w_2(x) & \\
acq & \ l_y \\
w_2(y) & \\
rel & \ l_x \\
rel & \ l_y
\end{align*}
\]

3

4
Isolation:

\[ \text{acq } l_x \leadsto \text{Simple locking} \]
\[ \text{acq } l_y \]
Two-phase locking (2 PL)

No release before ALL acquires

Correct