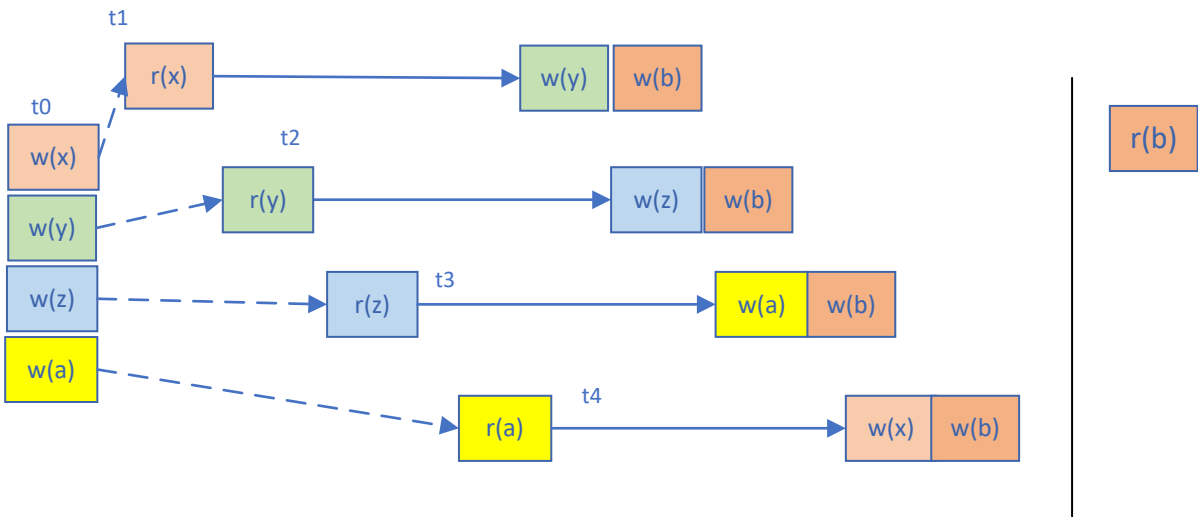


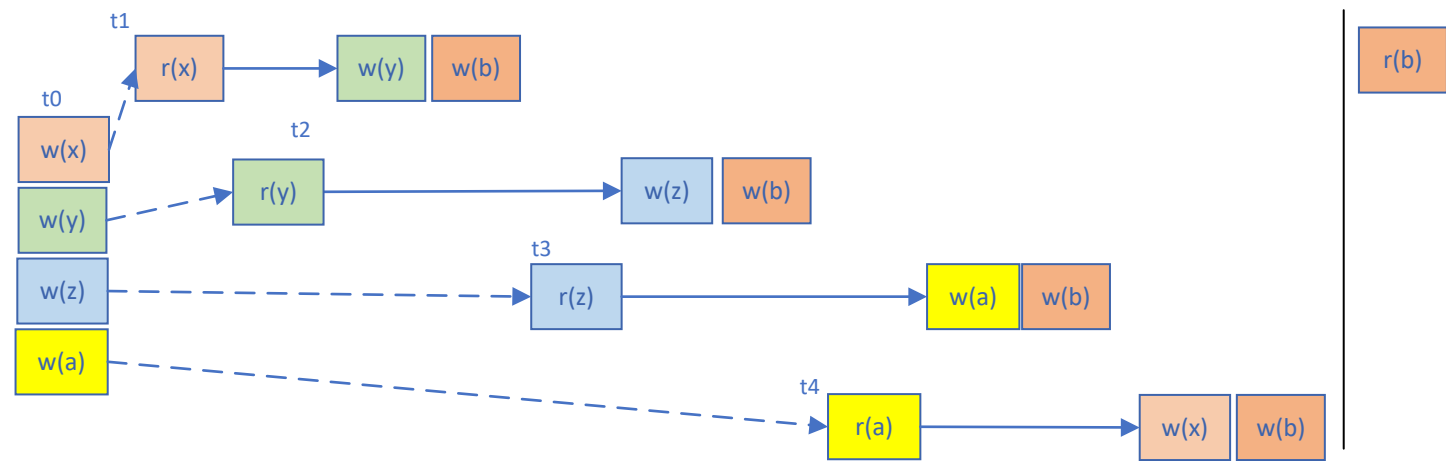
c→commit a→abort+理由になったtx bd→boundary  
r→read flag対象のtx w→write flag対象のtx



| write_crown          |      |      |          |                     |                  |                     |                  |                     |          |                     |          |                            |                      |                     |              |                     |
|----------------------|------|------|----------|---------------------|------------------|---------------------|------------------|---------------------|----------|---------------------|----------|----------------------------|----------------------|---------------------|--------------|---------------------|
| cascading_4tx_cycled |      |      |          |                     |                  |                     |                  |                     |          |                     |          |                            |                      |                     |              |                     |
|                      | occ4 |      | occ3ltx1 |                     | occ2ltx1<br>occ1 |                     | occ1ltx1<br>occ2 |                     | ltx1occ3 |                     | occ2ltx2 |                            | occ1ltx1<br>occ1ltx1 |                     | ltx1occ2ltx1 |                     |
| t1                   | OCC  | c    | OCC      | a:t4                | OCC              | c                   | OCC              | c                   | LTX      | <sup>c</sup><br>bd1 | OCC      | a:t4                       | OCC                  | a:t4                | LTX          | <sup>c</sup><br>bd1 |
| t2                   | OCC  | a:t1 | OCC      | c                   | OCC              | a:t1                | LTX              | <sup>c</sup><br>bd2 | OCC      | a:t1                | OCC      | c                          | LTX                  | <sup>c</sup><br>bd2 | OCC          | a:t1                |
| t3                   | OCC  | c    | OCC      | c                   | LTX              | <sup>c</sup><br>bd3 | OCC              | a:t2                | OCC      | c                   | LTX      | <sup>c</sup><br>bd3        | OCC                  | a:t2                | OCC          | c                   |
| t4                   | OCC  | a:t3 | LTX      | <sup>c</sup><br>bd4 | OCC              | a:t3                | OCC              | c                   | OCC      | a:t3                | LTX      | <sup>c</sup><br>bd3<br>rt3 | LTX                  | <sup>c</sup><br>bd4 | LTX          | <sup>c</sup><br>bd4 |
| read b               | t3   |      | t3       |                     | t1               |                     | t4               |                     | t3       |                     | t2       |                            | t2 or t4             |                     | t3           |                     |

|        | occ1ltx2<br>occ1 |                            | ltx1occ1<br>ltx1occ1 |                     | ltx2occ2 |                            | occ1ltx3 |                            | ltx1occ1ltx2 |                            | ltx2occ1ltx1 |                            | ltx3occ1 |                            | ltx4 |                                   |
|--------|------------------|----------------------------|----------------------|---------------------|----------|----------------------------|----------|----------------------------|--------------|----------------------------|--------------|----------------------------|----------|----------------------------|------|-----------------------------------|
| t1     | OCC              | c                          | LTX                  | <sup>c</sup><br>bd1 | LTX      | <sup>c</sup><br>bd1        | OCC      | a:t4                       | LTX          | <sup>c</sup><br>bd1        | LTX          | <sup>c</sup><br>bd1        | LTX      | <sup>c</sup><br>bd1        | LTX  | <sup>c</sup><br>bd1               |
| t2     | LTX              | <sup>c</sup><br>bd2        | OCC                  | a:t1                | LTX      | <sup>c</sup><br>bd1<br>rt1 | LTX      | <sup>c</sup><br>bd2        | OCC          | a:t1                       | LTX          | <sup>c</sup><br>bd1<br>rt1 | LTX      | <sup>c</sup><br>bd1<br>rt1 | LTX  | <sup>c</sup><br>bd1<br>rt1        |
| t3     | LTX              | <sup>c</sup><br>bd2<br>rt2 | LTX                  | <sup>c</sup><br>bd3 | OCC      | a:t2                       | LTX      | <sup>c</sup><br>bd2<br>rt2 | LTX          | <sup>c</sup><br>bd3        | OCC          | a:t2                       | LTX      | <sup>c</sup><br>bd1<br>rt2 | LTX  | <sup>c</sup><br>bd1<br>rt2        |
| t4     | OCC              | a:t3                       | OCC                  | a:t3                | OCC      | c                          | LTX      | <sup>c</sup><br>bd2<br>rt3 | LTX          | <sup>c</sup><br>bd3<br>rt3 | LTX          | <sup>c</sup><br>bd4        | OCC      | a:t3                       | LTX  | <sup>a</sup><br>bd1<br>rt2<br>wt1 |
| read b | t1               |                            | t1 or t3             |                     | t4       |                            | t2       |                            | t1 or t3     |                            | t1 or t4     |                            | t1       |                            | t1   |                                   |

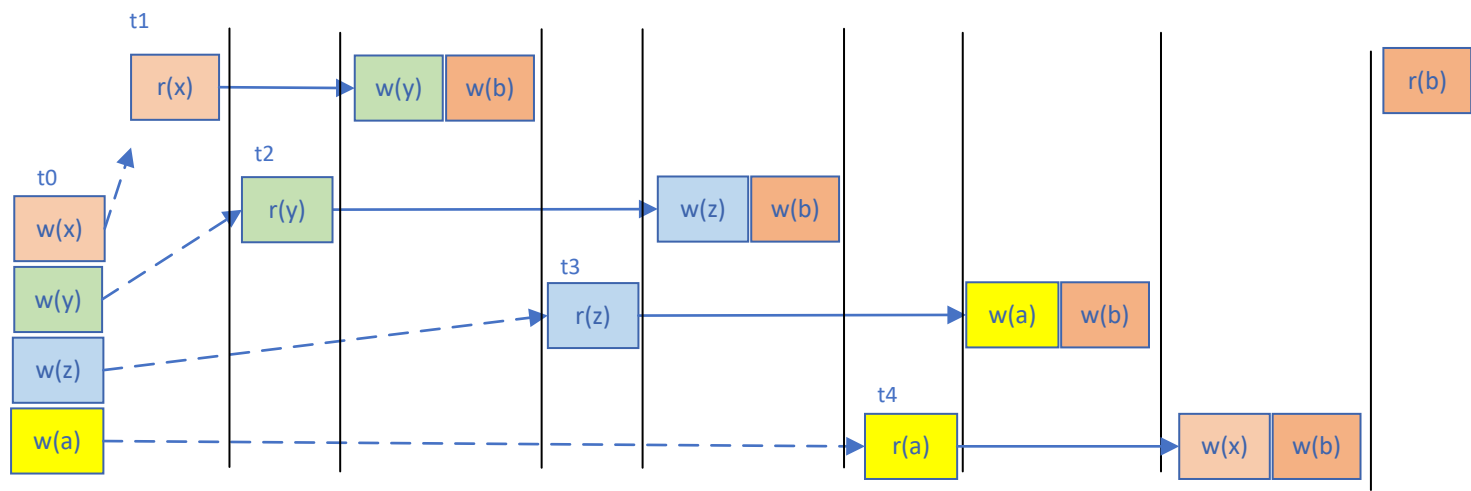
ex write\_crown.cascading\_4tx\_cycled.occ2ltx1occ1



| write_crown          |      |      |          |                     |                  |                     |                  |                     |          |                     |          |                             |                      |                     |              |                     |
|----------------------|------|------|----------|---------------------|------------------|---------------------|------------------|---------------------|----------|---------------------|----------|-----------------------------|----------------------|---------------------|--------------|---------------------|
| cascading_3tx_cycled |      |      |          |                     |                  |                     |                  |                     |          |                     |          |                             |                      |                     |              |                     |
|                      | occ4 |      | occ3ltx1 |                     | occ2ltx1<br>occ1 |                     | occ1ltx1<br>occ2 |                     | ltx1occ3 |                     | occ2ltx2 |                             | occ1ltx1<br>occ1ltx1 |                     | ltx1occ2ltx1 |                     |
| t1                   | OCC  | c    | OCC      | a:t4                | OCC              | c                   | OCC              | c                   | LTX      | <sup>c</sup><br>bd1 | OCC      | a:t4                        | OCC                  | a:t4                | LTX          | <sup>c</sup><br>bd1 |
| t2                   | OCC  | a:t1 | OCC      | c                   | OCC              | a:t1                | LTX              | <sup>c</sup><br>bd2 | OCC      | a:t1                | OCC      | c                           | LTX                  | <sup>c</sup><br>bd2 | OCC          | a:t1                |
| t3                   | OCC  | c    | OCC      | a:t2                | LTX              | <sup>c</sup><br>bd3 | OCC              | a:t2                | OCC      | c                   | LTX      | <sup>c</sup><br>bd3         | OCC                  | a:t2                | OCC          | c                   |
| t4                   | OCC  | a:t3 | LTX      | <sup>c</sup><br>bd4 | OCC              | a:t3                | OCC              | c                   | OCC      | a:t3                | LTX      | <sup>c</sup><br>bd3<br>r:t3 | LTX                  | <sup>c</sup><br>bd4 | LTX          | <sup>c</sup><br>bd4 |
| read b               | t3   |      | t2       |                     | t1               |                     | t4               |                     | t3       |                     | t2       |                             | t4                   |                     | t3           |                     |

|        | occ1ltx2<br>occ1 |                             | ltx1occ1<br>ltx1occ1 |                     | ltx2occ2 |                             | occ1ltx3 |                             | ltx1occ1ltx2 |                             | ltx2occ1ltx1 |                             | ltx3occ1 |                             | ltx4 |                                     |
|--------|------------------|-----------------------------|----------------------|---------------------|----------|-----------------------------|----------|-----------------------------|--------------|-----------------------------|--------------|-----------------------------|----------|-----------------------------|------|-------------------------------------|
| t1     | OCC              | c                           | LTX                  | <sup>c</sup><br>bd1 | LTX      | <sup>c</sup><br>bd1         | OCC      | a:t4                        | LTX          | <sup>c</sup><br>bd1         | LTX          | <sup>c</sup><br>bd1         | LTX      | <sup>c</sup><br>bd1         | LTX  | <sup>c</sup><br>bd1                 |
| t2     | LTX              | <sup>c</sup><br>bd2         | OCC                  | a:t1                | LTX      | <sup>c</sup><br>bd1<br>r:t1 | LTX      | <sup>c</sup><br>bd2         | OCC          | a:t1                        | LTX          | <sup>c</sup><br>bd1<br>r:t1 | LTX      | <sup>c</sup><br>bd1<br>r:t1 | LTX  | <sup>c</sup><br>bd1<br>r:t1         |
| t3     | LTX              | <sup>c</sup><br>bd2<br>r:t2 | LTX                  | <sup>c</sup><br>bd3 | OCC      | a:t2                        | LTX      | <sup>c</sup><br>bd2<br>r:t2 | LTX          | <sup>c</sup><br>bd3         | OCC          | a:t2                        | LTX      | <sup>c</sup><br>bd1<br>r:t2 | LTX  | <sup>c</sup><br>bd1<br>r:t2         |
| t4     | OCC              | a:t3                        | OCC                  | a:t3                | OCC      | c                           | LTX      | <sup>c</sup><br>bd2<br>r:t3 | LTX          | <sup>c</sup><br>bd3<br>r:t3 | LTX          | <sup>c</sup><br>bd4         | OCC      | a:t3                        | LTX  | <sup>a</sup><br>bd1<br>r:t2<br>w:t1 |
| read b | t1               |                             | t1 or t3             |                     | t4       |                             | t2       |                             | t1 or t3     |                             | t1 or t4     |                             | t1       |                             | t1   |                                     |

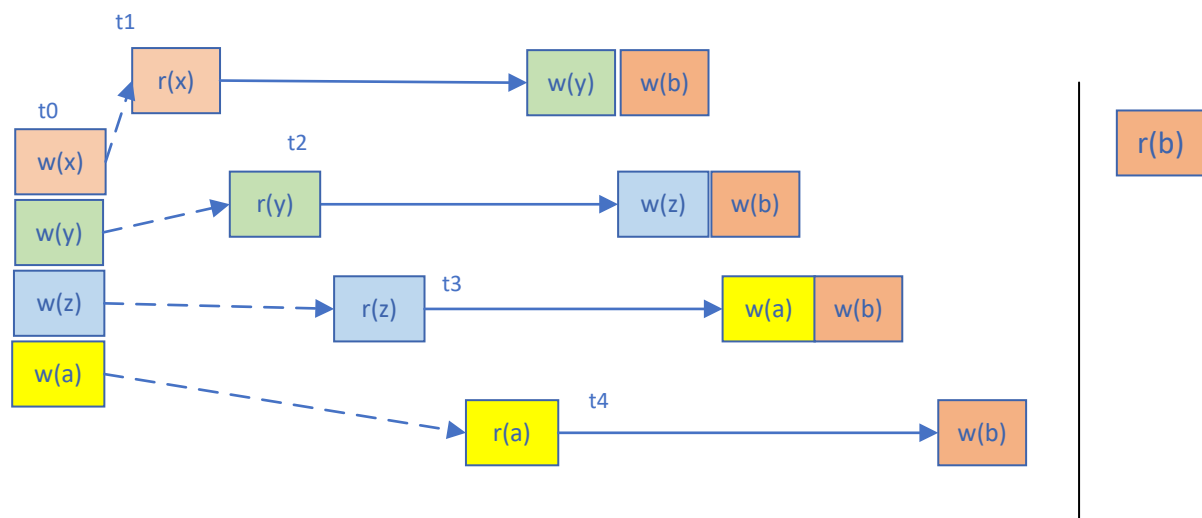


| write_crown                          |      |      |          |                      |                  |                     |                  |                     |          |                     |          |                             |                      |                     |              |                     |
|--------------------------------------|------|------|----------|----------------------|------------------|---------------------|------------------|---------------------|----------|---------------------|----------|-----------------------------|----------------------|---------------------|--------------|---------------------|
| cascading_3tx_1epoch_per_1ope_cycled |      |      |          |                      |                  |                     |                  |                     |          |                     |          |                             |                      |                     |              |                     |
|                                      | occ4 |      | occ3ltx1 |                      | occ2ltx1<br>occ1 |                     | occ1ltx1<br>occ2 |                     | ltx1occ3 |                     | occ2ltx2 |                             | occ1ltx1<br>occ1ltx1 |                     | ltx1occ2ltx1 |                     |
| t1                                   | OCC  | c    | OCC      | c                    | OCC              | c                   | OCC              | c                   | LTX      | <sup>c</sup><br>bd1 | OCC      | c                           | OCC                  | c                   | LTX          | <sup>c</sup><br>bd1 |
| t2                                   | OCC  | a:t1 | OCC      | a:t1                 | OCC              | a:t1                | LTX              | <sup>c</sup><br>bd2 | OCC      | a:t1                | OCC      | a:t1                        | LTX                  | <sup>c</sup><br>bd2 | OCC          | a:t1                |
| t3                                   | OCC  | c    | OCC      | c                    | LTX              | <sup>c</sup><br>bd3 | OCC              | a:t2                | OCC      | c                   | LTX      | <sup>c</sup><br>bd3         | OCC                  | a:t2                | OCC          | c                   |
| t4                                   | OCC  | a:t3 | LTX      | <sup>c</sup><br>bd:4 | OCC              | a:t3                | OCC              | c                   | OCC      | a:t3                | LTX      | <sup>c</sup><br>bd3<br>r:t3 | LTX                  | <sup>c</sup><br>bd4 | LTX          | <sup>c</sup><br>bd4 |
| read b                               | t3   |      | t3       |                      | t3               |                     | t4               |                     | t3       |                     | t3       |                             | t4                   |                     | t3           |                     |

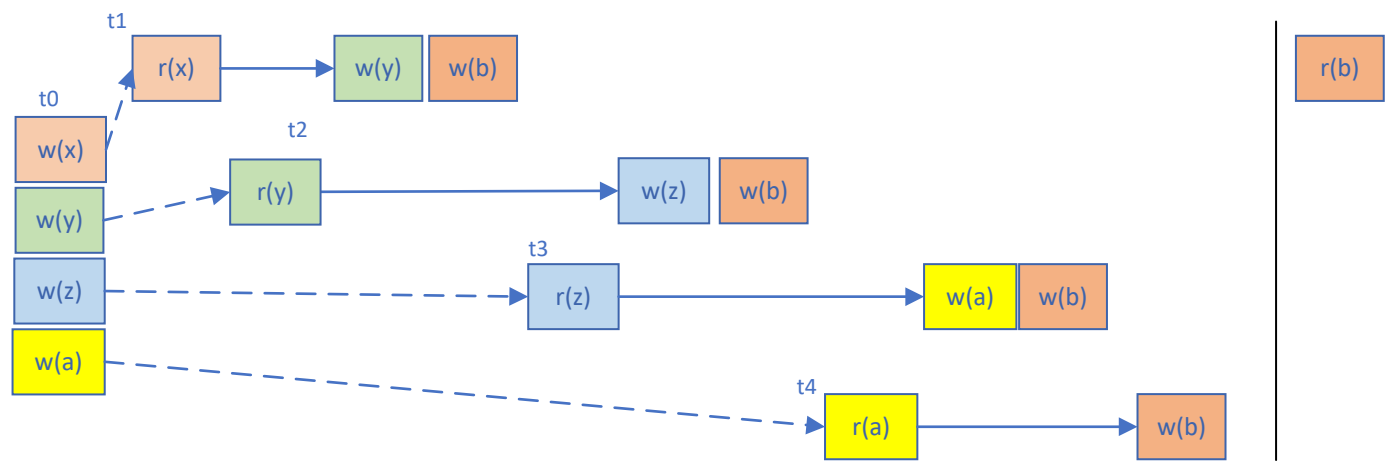
|        | occ1ltx2<br>occ1 |                             | ltx1occ1<br>ltx1occ1 |                     | ltx2occ2 |                             | occ1ltx3 |                                     | ltx1occ1ltx2 |                             | ltx2occ1ltx1 |                             | ltx3occ1 |                             | ltx4 |                                     |
|--------|------------------|-----------------------------|----------------------|---------------------|----------|-----------------------------|----------|-------------------------------------|--------------|-----------------------------|--------------|-----------------------------|----------|-----------------------------|------|-------------------------------------|
| t1     | OCC              | c                           | LTX                  | <sup>c</sup><br>bd1 | LTX      | <sup>c</sup><br>bd1         | OCC      | c                                   | LTX          | <sup>c</sup><br>bd1         | LTX          | <sup>c</sup><br>bd1         | LTX      | <sup>c</sup><br>bd1         | LTX  | <sup>c</sup><br>bd1                 |
| t2     | LTX              | <sup>c</sup><br>bd2         | OCC                  | a:t1                | LTX      | <sup>c</sup><br>bd1<br>r:t1 | LTX      | <sup>c</sup><br>bd2                 | OCC          | a:t1                        | LTX          | <sup>c</sup><br>bd1<br>r:t1 | LTX      | <sup>c</sup><br>bd1<br>r:t1 | LTX  | <sup>c</sup><br>bd1<br>r:t1         |
| t3     | LTX              | <sup>c</sup><br>bd2<br>r:t2 | LTX                  | <sup>c</sup><br>bd3 | OCC      | a:t2                        | LTX      | <sup>c</sup><br>bd2<br>r:t2         | LTX          | <sup>c</sup><br>bd3         | OCC          | a:t2                        | LTX      | <sup>c</sup><br>bd1<br>r:t2 | LTX  | <sup>c</sup><br>bd1<br>r:t2         |
| t4     | OCC              | a:t3                        | OCC                  | a:t3                | OCC      | c                           | LTX      | <sup>a</sup><br>bd2<br>r:t3<br>w:t1 | LTX          | <sup>c</sup><br>bd3<br>r:t3 | LTX          | <sup>c</sup><br>bd4         | OCC      | a:t3                        | LTX  | <sup>a</sup><br>bd1<br>r:t2<br>w:t1 |
| read b | t1               |                             | t3                   |                     | t4       |                             | t1       |                                     | t3           |                             | t4           |                             | t1       |                             | t1   |                                     |

ex write\_crown.cascading\_3tx\_1epoch\_per\_1ope.occ2ltx1occ1



| write_crown            |                  |                             |                      |                     |                  |                             |                  |                             |              |                             |              |                             |                      |                             |              |                             |
|------------------------|------------------|-----------------------------|----------------------|---------------------|------------------|-----------------------------|------------------|-----------------------------|--------------|-----------------------------|--------------|-----------------------------|----------------------|-----------------------------|--------------|-----------------------------|
| cascading_4tx_uncylced |                  |                             |                      |                     |                  |                             |                  |                             |              |                             |              |                             |                      |                             |              |                             |
|                        | occ4             |                             | occ3ltx1             |                     | occ2ltx1<br>occ1 |                             | occ1ltx1<br>occ2 |                             | ltx1occ3     |                             | occ2ltx2     |                             | occ1ltx1<br>occ1ltx1 |                             | ltx1occ2ltx1 |                             |
| t1                     | OCC              | c                           | OCC                  | c                   | OCC              | c                           | OCC              | c                           | LTX          | <sup>c</sup><br>bd1         | OCC          | c                           | OCC                  | c                           | LTX          | <sup>c</sup><br>bd1         |
| t2                     | OCC              | a:t1                        | OCC                  | a:t1                | OCC              | a:t1                        | LTX              | <sup>c</sup><br>bd2         | OCC          | a:t1                        | OCC          | a:t1                        | LTX                  | <sup>c</sup><br>bd2         | OCC          | a:t1                        |
| t3                     | OCC              | c                           | OCC                  | c                   | LTX              | <sup>c</sup><br>bd3         | OCC              | a:t2                        | OCC          | c                           | LTX          | <sup>c</sup><br>bd3         | OCC                  | a:t2                        | OCC          | c                           |
| t4                     | OCC              | a:t3                        | LTX                  | <sup>c</sup><br>bd4 | OCC              | a:t3                        | OCC              | c                           | OCC          | a:t3                        | LTX          | <sup>c</sup><br>bd3<br>r:t3 | LTX                  | <sup>c</sup><br>bd4         | LTX          | <sup>c</sup><br>bd4         |
| read b                 | t4               |                             | t3                   |                     | t1               |                             | t4               |                             | t3           |                             | t1           |                             | t1                   |                             | t3           |                             |
|                        | occ1ltx2<br>occ1 |                             | ltx1occ1<br>ltx1occ1 |                     | ltx2occ2         |                             | occ1ltx3         |                             | ltx1occ1ltx2 |                             | ltx2occ1ltx1 |                             | ltx3occ1             |                             | ltx4         |                             |
| t1                     | OCC              | c                           | LTX                  | <sup>c</sup><br>bd1 | LTX              | <sup>c</sup><br>bd1         | OCC              | c                           | LTX          | <sup>c</sup><br>bd1         | LTX          | <sup>c</sup><br>bd1         | LTX                  | <sup>c</sup><br>bd1         | LTX          | <sup>c</sup><br>bd1         |
| t2                     | LTX              | <sup>c</sup><br>bd2         | OCC                  | a:t1                | LTX              | <sup>c</sup><br>bd1<br>r:t1 | LTX              | <sup>c</sup><br>bd2         | OCC          | a:t1                        | LTX          | <sup>c</sup><br>bd1<br>r:t1 | LTX                  | <sup>c</sup><br>bd1<br>r:t1 | LTX          | <sup>c</sup><br>bd1<br>r:t1 |
| t3                     | LTX              | <sup>c</sup><br>bd2<br>r:t2 | LTX                  | <sup>c</sup><br>bd3 | OCC              | a:t2                        | LTX              | <sup>c</sup><br>bd2<br>r:t2 | LTX          | <sup>c</sup><br>bd3         | OCC          | a:t2                        | LTX                  | <sup>c</sup><br>bd1<br>r:t2 | LTX          | <sup>c</sup><br>bd1<br>r:t2 |
| t4                     | OCC              | a:t3                        | OCC                  | a:t3                | OCC              | c                           | LTX              | <sup>c</sup><br>bd2<br>r:t3 | LTX          | <sup>c</sup><br>bd3<br>r:t3 | LTX          | <sup>c</sup><br>bd4         | OCC                  | a:t3                        | LTX          | <sup>c</sup><br>bd1<br>r:t3 |
| read b                 | t1               |                             | t1 or t3             |                     | t4               |                             | t1               |                             | t1 or t3     |                             | t1 or t4     |                             | t1                   |                             | t1           |                             |

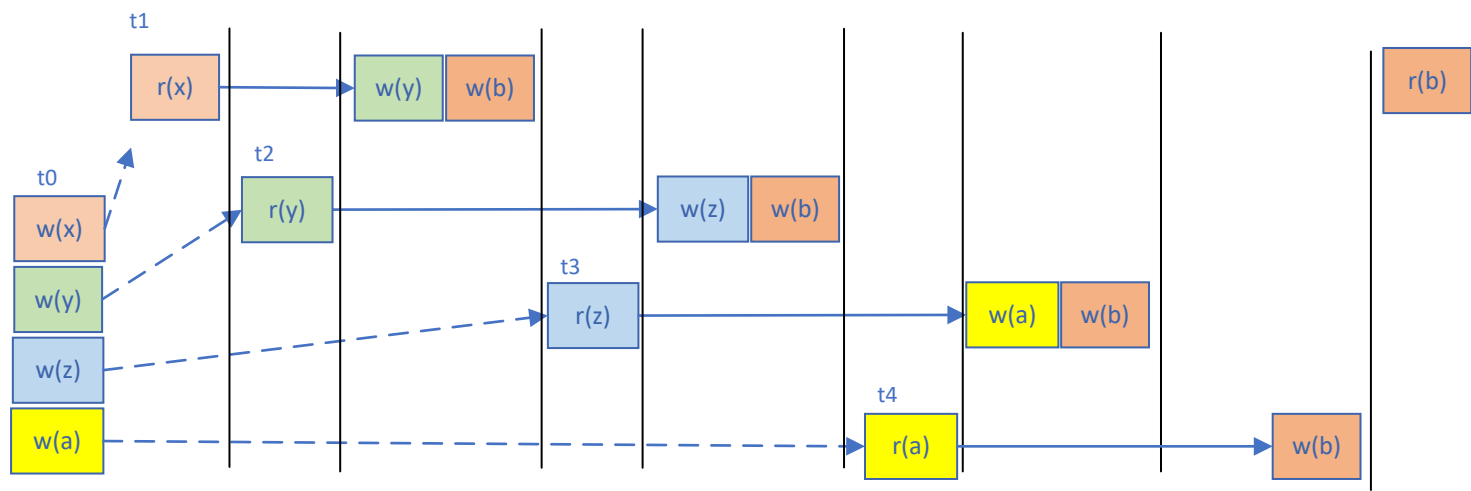
ex write\_crown.cascading\_4tx\_uncylced.occ2ltx1occ1



| write_crown            |      |      |          |                     |                  |                     |                  |                     |          |                     |          |                             |                      |                     |              |                     |
|------------------------|------|------|----------|---------------------|------------------|---------------------|------------------|---------------------|----------|---------------------|----------|-----------------------------|----------------------|---------------------|--------------|---------------------|
| cascading_3tx_uncycled |      |      |          |                     |                  |                     |                  |                     |          |                     |          |                             |                      |                     |              |                     |
|                        | occ4 |      | occ3ltx1 |                     | occ2ltx1<br>occ1 |                     | occ1ltx1<br>occ2 |                     | ltx1occ3 |                     | occ2ltx2 |                             | occ1ltx1<br>occ1ltx1 |                     | ltx1occ2ltx1 |                     |
| t1                     | OCC  | c    | OCC      | c                   | OCC              | c                   | OCC              | c                   | LTX      | <sup>c</sup><br>bd1 | OCC      | c                           | OCC                  | c                   | LTX          | <sup>c</sup><br>bd1 |
| t2                     | OCC  | a:t1 | OCC      | c                   | OCC              | a:t1                | LTX              | <sup>c</sup><br>bd2 | OCC      | a:t1                | OCC      | a:t1                        | LTX                  | <sup>c</sup><br>bd2 | OCC          | a:t1                |
| t3                     | OCC  | c    | OCC      | a:t2                | LTX              | <sup>c</sup><br>bd3 | OCC              | a:t2                | OCC      | c                   | LTX      | <sup>c</sup><br>bd3         | OCC                  | a:t2                | OCC          | c                   |
| t4                     | OCC  | a:t3 | LTX      | <sup>c</sup><br>bd4 | OCC              | a:t3                | OCC              | c                   | OCC      | a:t3                | LTX      | <sup>c</sup><br>bd3<br>r:t3 | LTX                  | <sup>c</sup><br>bd4 | LTX          | <sup>c</sup><br>bd4 |
| read b                 | t4   |      | t2       |                     | t1               |                     | t4               |                     | t3       |                     | t1       |                             | t1                   |                     | t3           |                     |

|        | occ1ltx2<br>occ1 |                             | ltx1occ1<br>ltx1occ1 |                     | ltx2occ2 |                             | occ1ltx3 |                             | ltx1occ1ltx2 |                             | ltx2occ1ltx1 |                             | ltx3occ1 |                             | ltx4 |                             |
|--------|------------------|-----------------------------|----------------------|---------------------|----------|-----------------------------|----------|-----------------------------|--------------|-----------------------------|--------------|-----------------------------|----------|-----------------------------|------|-----------------------------|
| t1     | OCC              | c                           | LTX                  | <sup>c</sup><br>bd1 | LTX      | <sup>c</sup><br>bd1         | OCC      | c                           | LTX          | <sup>c</sup><br>bd1         | LTX          | <sup>c</sup><br>bd1         | LTX      | <sup>c</sup><br>bd1         | LTX  | <sup>c</sup><br>bd1         |
| t2     | LTX              | <sup>c</sup><br>bd2         | OCC                  | a:t1                | LTX      | <sup>c</sup><br>bd1<br>r:t1 | LTX      | <sup>c</sup><br>bd2         | OCC          | a:t1                        | LTX          | <sup>c</sup><br>bd1<br>r:t1 | LTX      | <sup>c</sup><br>bd1<br>r:t1 | LTX  | <sup>c</sup><br>bd1<br>r:t1 |
| t3     | LTX              | <sup>c</sup><br>bd2<br>r:t2 | LTX                  | <sup>c</sup><br>bd3 | OCC      | a:t2                        | LTX      | <sup>c</sup><br>bd2<br>r:t2 | LTX          | <sup>c</sup><br>bd3         | OCC          | a:t2                        | LTX      | <sup>c</sup><br>bd1<br>r:t2 | LTX  | <sup>c</sup><br>bd1<br>r:t2 |
| t4     | OCC              | a:t3                        | OCC                  | a:t3                | OCC      | c                           | LTX      | <sup>c</sup><br>bd2<br>r:t3 | LTX          | <sup>c</sup><br>bd3<br>r:t3 | LTX          | <sup>c</sup><br>bd4         | OCC      | a:t3                        | LTX  | <sup>c</sup><br>bd1<br>r:t3 |
| read b | t1               |                             | t1 or t3             |                     | t4       |                             | t1       |                             | t1 or t3     |                             | t1 or t4     |                             | t1       |                             | t1   |                             |



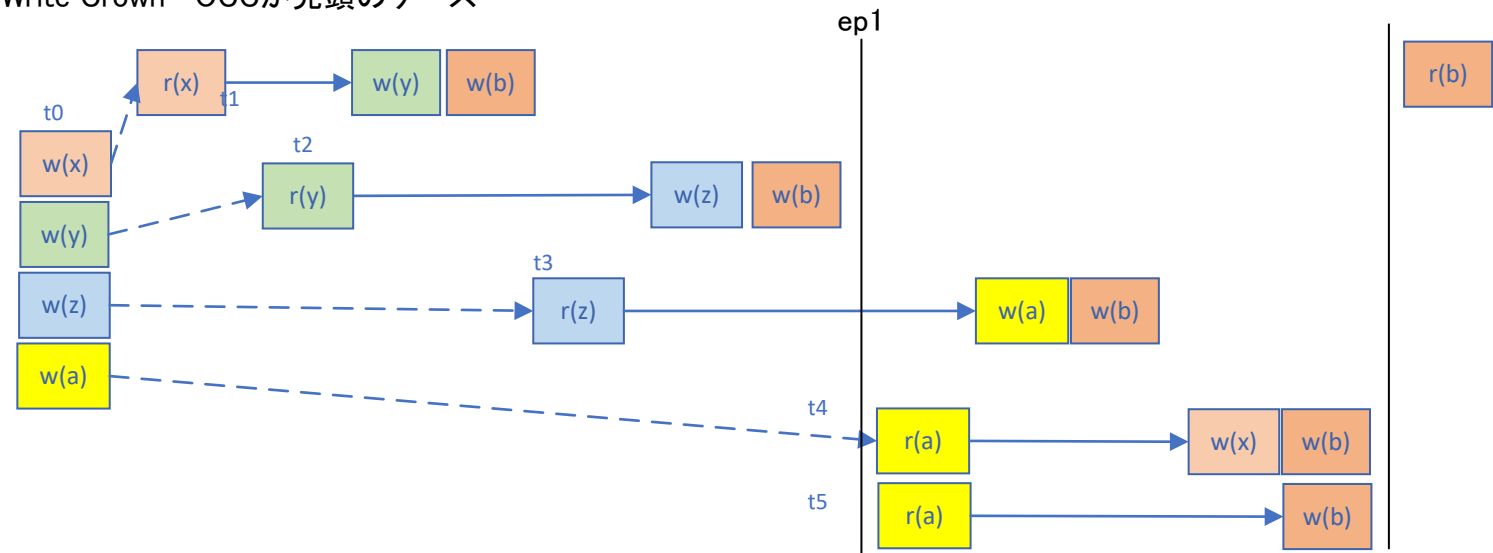
| write_crown                            |      |      |          |                     |                  |                     |                  |                     |          |                     |          |                             |                      |                     |              |                     |  |
|--|------|------|----------|---------------------|------------------|---------------------|------------------|---------------------|----------|---------------------|----------|-----------------------------|----------------------|---------------------|--------------|---------------------|--|
| cascading_3tx_1epoch_per_1ope_uncycled |      |      |          |                     |                  |                     |                  |                     |          |                     |          |                             |                      |                     |              |                     |  |
|  | occ4 |      | occ3ltx1 |                     | occ2ltx1<br>occ1 |                     | occ1ltx1<br>occ2 |                     | ltx1occ3 |                     | occ2ltx2 |                             | occ1ltx1<br>occ1ltx1 |                     | ltx1occ2ltx1 |                     |  |
| t1                                     | OCC  | c    | OCC      | c                   | OCC              | c                   | OCC              | c                   | LTX      | <sup>c</sup><br>bd1 | OCC      | c                           | OCC                  | c                   | LTX          | <sup>c</sup><br>bd1 |  |
| t2                                     | OCC  | a:t1 | OCC      | a:t1                | OCC              | a:t1                | LTX              | <sup>c</sup><br>bd2 | OCC      | a:t1                | OCC      | a:t1                        | LTX                  | <sup>c</sup><br>bd2 | OCC          | a:t1                |  |
| t3                                     | OCC  | c    | OCC      | c                   | LTX              | <sup>c</sup><br>bd3 | OCC              | a:t2                | OCC      | c                   | LTX      | <sup>c</sup><br>bd3         | OCC                  | a:t2                | OCC          | c                   |  |
| t4                                     | OCC  | a:t3 | LTX      | <sup>c</sup><br>bd4 | OCC              | a:t3                | OCC              | c                   | OCC      | a:t3                | LTX      | <sup>c</sup><br>bd3<br>r:t3 | LTX                  | <sup>c</sup><br>bd4 | LTX          | <sup>c</sup><br>bd4 |  |
| read b                                 | t3   |      | t3       |                     | t3               |                     | t4               |                     | t3       |                     | t3       |                             | t4                   |                     | t3           |                     |  |

|        | occ1ltx2<br>occ1 |                             | ltx1occ1<br>ltx1occ1 |                     | ltx2occ2 |                             | occ1ltx3 |                                     | ltx1occ1ltx2 |                             | ltx2occ1ltx1 |                             | ltx3occ1 |                             | ltx4 |                             |  |
|--------|------------------|-----------------------------|----------------------|---------------------|----------|-----------------------------|----------|-------------------------------------|--------------|-----------------------------|--------------|-----------------------------|----------|-----------------------------|------|-----------------------------|--|
| t1     | OCC              | c                           | LTX                  | <sup>c</sup><br>bd1 | LTX      | <sup>c</sup><br>bd1         | OCC      | c                                   | LTX          | <sup>c</sup><br>bd1         | LTX          | <sup>c</sup><br>bd1         | LTX      | <sup>c</sup><br>bd1         | LTX  | <sup>c</sup><br>bd1         |  |
| t2     | LTX              | <sup>c</sup><br>bd2         | OCC                  | a:t1                | LTX      | <sup>c</sup><br>bd1<br>r:t1 | LTX      | <sup>c</sup><br>bd2                 | OCC          | a:t1                        | LTX          | <sup>c</sup><br>bd1<br>r:t1 | LTX      | <sup>c</sup><br>bd1<br>r:t1 | LTX  | <sup>c</sup><br>bd1<br>r:t1 |  |
| t3     | LTX              | <sup>c</sup><br>bd2<br>r:t2 | LTX                  | <sup>c</sup><br>bd3 | OCC      | a:t2                        | LTX      | <sup>c</sup><br>bd2<br>r:t2         | LTX          | <sup>c</sup><br>bd3         | OCC          | a:t2                        | LTX      | <sup>c</sup><br>bd1<br>r:t2 | LTX  | <sup>c</sup><br>bd1<br>r:t2 |  |
| t4     | OCC              | a:t3                        | OCC                  | a:t3                | OCC      | c                           | LTX      | <sup>a</sup><br>bd2<br>r:t3<br>w:t1 | LTX          | <sup>c</sup><br>bd3<br>r:t3 | LTX          | <sup>c</sup><br>bd4         | OCC      | a:t3                        | LTX  | <sup>c</sup><br>bd1<br>r:t3 |  |
| read b | t1               |                             | t3                   |                     | t4       |                             | t1       |                                     | t3           |                             | t4           |                             | t1       |                             | t1   |                             |  |

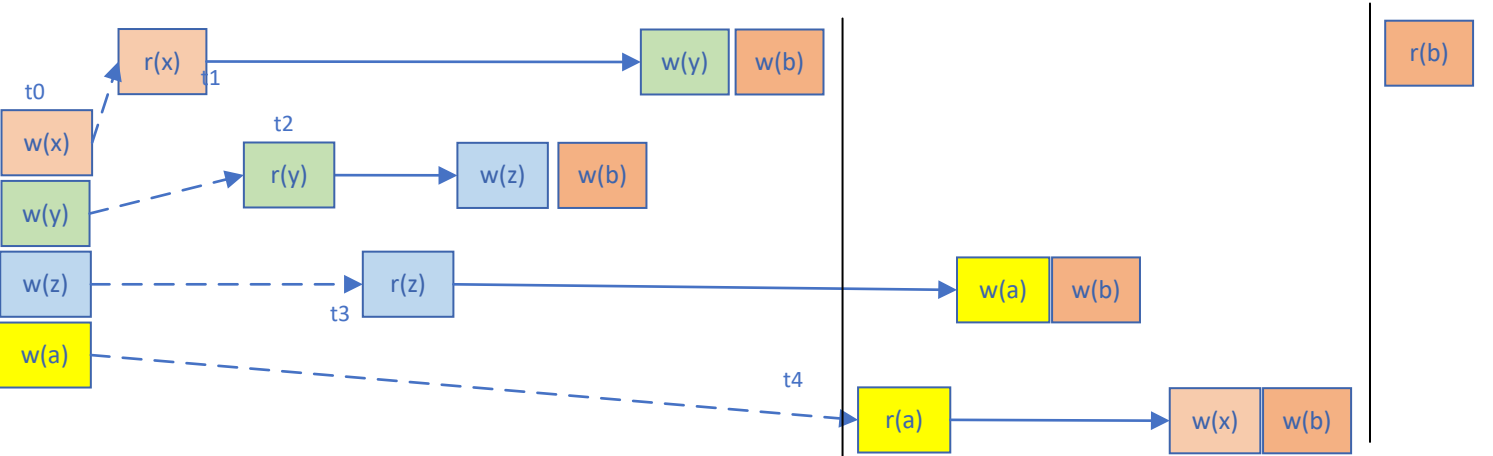
ex write\_crown.cascading\_all\_3tx\_1epoch\_per\_1ope.occ2ltx1occ1

Write Crown OCCが先頭のケース



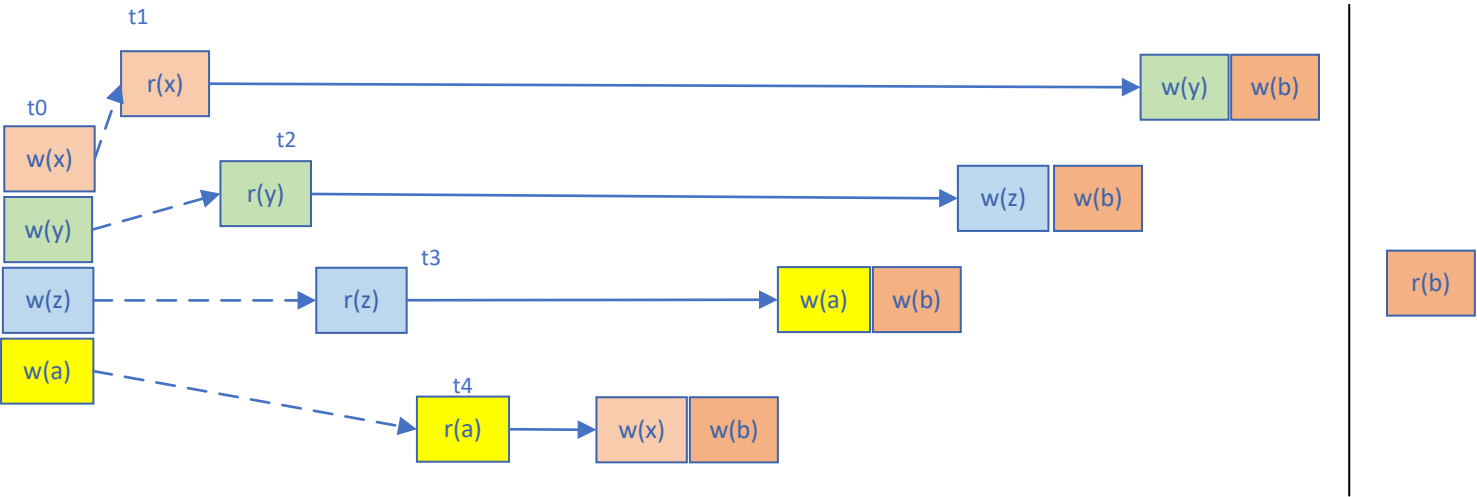
| write_crown              |     |                  |
|--------------------------|-----|------------------|
| start_with_occ_cascading |     |                  |
| t1                       | OCC | c                |
| t2                       | LTX | c bd:2           |
| t3                       | LTX | c bd:2 r:t2      |
| t4                       | LTX | a bd:2 r:t3 w:t1 |
| t5                       | LTX | c bd:2 r:t3      |
| read b                   | t1  |                  |

Write Crown OCCが先頭のケースでオーバーラップする



| write_crown                |     |                  |
|----------------------------|-----|------------------|
| start_with_2occ_overlapped |     |                  |
| t1                         | OCC | c                |
| t2                         | OCC | c                |
| t3                         | LTX | c bd:3           |
| t4                         | LTX | a bd:3 r:t3 w:t1 |
| read b                     | t1  |                  |

Write Crown  
overlapped\_all\_4tx\_cycled



| write_crown           |      |      |          |                     |                  |                     |                  |                     |          |                     |          |                             |                      |                     |              |                     |
|-----------------------|------|------|----------|---------------------|------------------|---------------------|------------------|---------------------|----------|---------------------|----------|-----------------------------|----------------------|---------------------|--------------|---------------------|
| overlapped_4tx_cycled |      |      |          |                     |                  |                     |                  |                     |          |                     |          |                             |                      |                     |              |                     |
|                       | occ4 |      | occ3ltx1 |                     | occ2ltx1<br>occ1 |                     | occ1ltx1<br>occ2 |                     | ltx1occ3 |                     | occ2ltx2 |                             | occ1ltx1<br>occ1ltx1 |                     | ltx1occ2ltx1 |                     |
| t1                    | OCC  | a:t4 | OCC      | a:t4                | OCC              | c                   | OCC              | a:t4                | LTX      | <sup>c</sup><br>bd1 | OCC      | a:t4                        | OCC                  | a:t4                | LTX          | <sup>c</sup><br>bd1 |
| t2                    | OCC  | c    | OCC      | c                   | OCC              | c                   | LTX              | <sup>c</sup><br>bd2 | OCC      | a:t1                | OCC      | c                           | LTX                  | <sup>c</sup><br>bd2 | OCC          | a:t1                |
| t3                    | OCC  | c    | OCC      | c                   | LTX              | <sup>c</sup><br>bd3 | OCC              | a:t2                | OCC      | c                   | LTX      | <sup>c</sup><br>bd3         | OCC                  | a:t2                | OCC          | c                   |
| t4                    | OCC  | c    | LTX      | <sup>c</sup><br>bd4 | OCC              | a:t3                | OCC              | c                   | OCC      | c                   | LTX      | <sup>c</sup><br>bd3<br>r:t3 | LTX                  | <sup>c</sup><br>bd4 | LTX          | <sup>c</sup><br>bd4 |
| read b                | t2   |      | t2       |                     | t1               |                     | t4               |                     | t3       |                     | t2       |                             | t4                   |                     | t3           |                     |

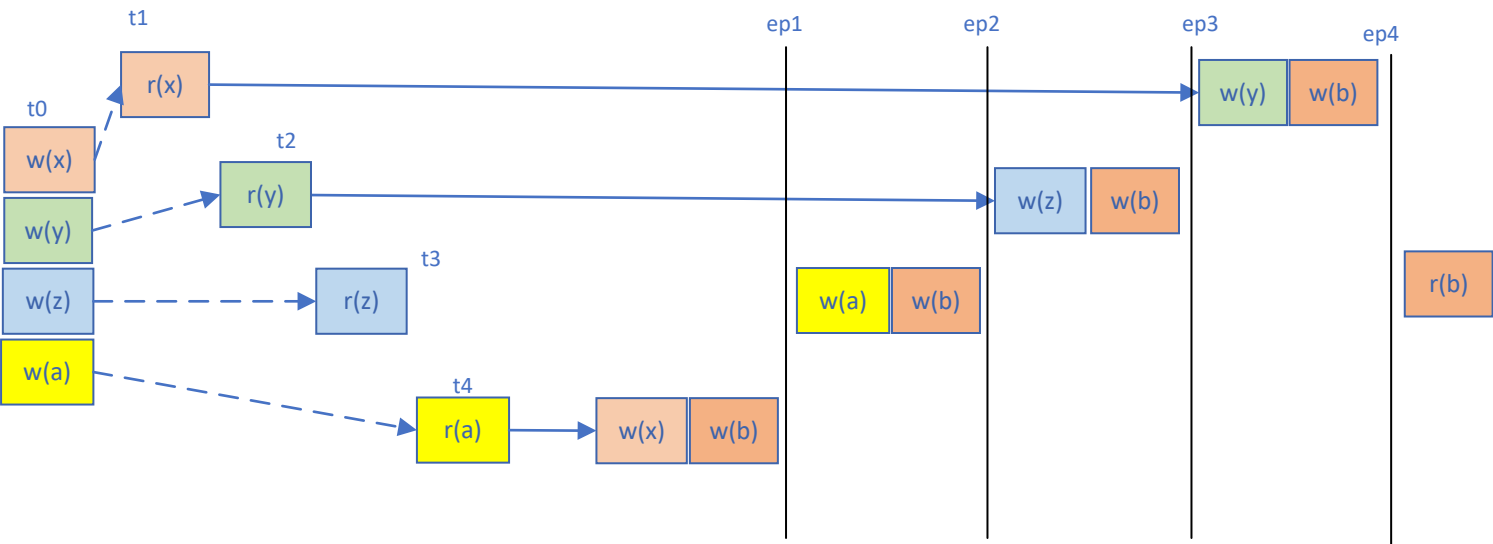
|        | occ1ltx2<br>occ1 |                             | ltx1occ1<br>ltx1occ1 |                     | ltx2occ2 |                             | occ1ltx3 |                             | ltx1occ1ltx2 |                             | ltx2occ1ltx1 |                             | ltx3occ1 |                             | ltx4 |                             |
|--------|------------------|-----------------------------|----------------------|---------------------|----------|-----------------------------|----------|-----------------------------|--------------|-----------------------------|--------------|-----------------------------|----------|-----------------------------|------|-----------------------------|
| t1     | OCC              | c                           | LTX                  | <sup>c</sup><br>bd1 | LTX      | <sup>c</sup><br>bd1         | OCC      | a:t4                        | LTX          | <sup>c</sup><br>bd1         | LTX          | <sup>c</sup><br>bd1         | LTX      | <sup>c</sup><br>bd1         | LTX  | <sup>c</sup><br>bd1         |
| t2     | LTX              | <sup>c</sup><br>bd2         | OCC                  | a:t1                | LTX      | <sup>c</sup><br>bd1<br>r:t1 | LTX      | <sup>c</sup><br>bd2         | OCC          | a:t1                        | LTX          | <sup>c</sup><br>bd1<br>r:t1 | LTX      | <sup>c</sup><br>bd1<br>r:t1 | LTX  | <sup>c</sup><br>bd1<br>r:t1 |
| t3     | LTX              | <sup>c</sup><br>bd2<br>r:t2 | LTX                  | <sup>c</sup><br>bd3 | OCC      | a:t2                        | LTX      | <sup>c</sup><br>bd2<br>r:t2 | LTX          | <sup>c</sup><br>bd3         | OCC          | a:t2                        | LTX      | <sup>c</sup><br>bd1<br>r:t2 | LTX  | <sup>c</sup><br>bd1<br>r:t2 |
| t4     | OCC              | a:t3                        | OCC                  | a:t3                | OCC      | c                           | LTX      | <sup>c</sup><br>bd2<br>r:t3 | LTX          | <sup>c</sup><br>bd3<br>r:t3 | LTX          | <sup>c</sup><br>bd4         | OCC      | a:t3                        | LTX  | a<br>bd1<br>r:t2<br>wt1     |
| read b | t1               |                             | t1 or t3             |                     | t4       |                             | t2       |                             | t1 or t3     |                             | t1 or t4     |                             | t1       |                             | t1   |                             |



on going tx =go  
waiting tx = w  
waited tx = /w

OCCはできるだけ  
early abortさせている

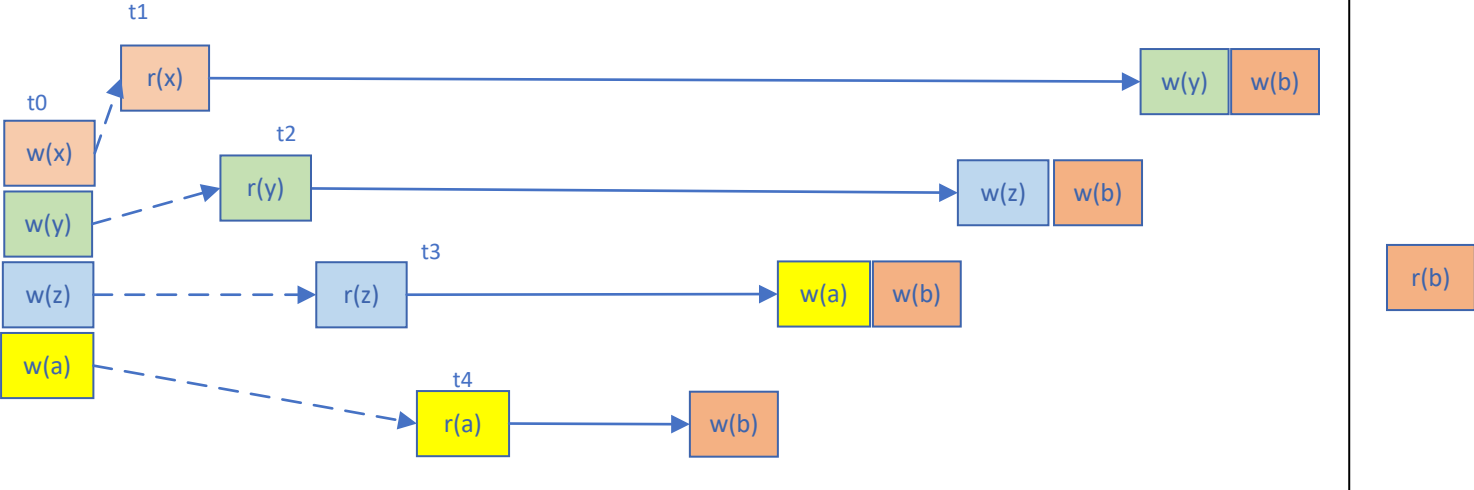
Write Crown overlapped\_all\_4tx\_with\_epoch\_cycled



| write_crown                      |          |      |          |                     |                  |                     |                  |                     |          |                     |          |                             |                      |                     |              |                     |
|----------------------------------|----------|------|----------|---------------------|------------------|---------------------|------------------|---------------------|----------|---------------------|----------|-----------------------------|----------------------|---------------------|--------------|---------------------|
| overlapped_4tx_with_epoch_cycled |          |      |          |                     |                  |                     |                  |                     |          |                     |          |                             |                      |                     |              |                     |
|                                  | occ4     |      | occ3ltx1 |                     | occ2ltx1<br>occ1 |                     | occ1ltx1<br>occ2 |                     | ltx1occ3 |                     | occ2ltx2 |                             | occ1ltx1<br>occ1ltx1 |                     | ltx1occ2ltx1 |                     |
| t1                               | OCC      | a:t4 | OCC      | a:t4                | OCC              | c                   | OCC              | a:t4                | LTX      | <sup>c</sup><br>bd1 | OCC      | a:t4                        | OCC                  | a:t4                | LTX          | <sup>c</sup><br>bd1 |
| t2                               | OCC      | c    | OCC      | c                   | OCC              | c                   | LTX              | <sup>c</sup><br>bd2 | OCC      | a:t1                | OCC      | c                           | LTX                  | <sup>c</sup><br>bd2 | OCC          | a:t1                |
| t3                               | OCC      | c    | OCC      | c                   | LTX              | <sup>c</sup><br>bd3 | OCC              | a:t2                | OCC      | c                   | LTX      | <sup>c</sup><br>bd3         | OCC                  | a:t2                | OCC          | c                   |
| t4                               | OCC      | c    | LTX      | <sup>c</sup><br>bd4 | OCC              | a:t3                | OCC              | c                   | OCC      | c                   | LTX      | <sup>c</sup><br>bd3<br>r:t3 | LTX                  | <sup>c</sup><br>bd4 | LTX          | <sup>c</sup><br>bd4 |
| read b                           | t2       |      | t2       |                     | t1               |                     | t4               |                     | t3       |                     | t2       |                             | t4                   |                     | t3           |                     |
| ep1                              | go:t2/t3 |      | go:t2/t3 |                     | go:t1/t2/t3      |                     | go:t2            |                     | go:t1/t3 |                     | go:t2/t3 |                             | go:t2                |                     | go:t1/t3     |                     |
|                                  | w:NA     |      | w:NA     |                     | w:NA             |                     | w:NA             |                     | w:NA     |                     | w:t4     |                             | w:NA                 |                     | w:NA         |                     |
|                                  | /w:NA    |      | /w:NA    |                     | /w:NA            |                     | /w:NA            |                     | /w:NA    |                     | /w:t3    |                             | /w:NA                |                     | /w:NA        |                     |
| ep2                              | go:t2    |      | go:t2    |                     | go:t1/t2         |                     | go:t2            |                     | go:t1    |                     | go:t2    |                             | go:t2                |                     | go:t1        |                     |
|                                  | w:NA     |      | w:NA     |                     | w:NA             |                     | w:NA             |                     | w:NA     |                     | w:NA     |                             | w:NA                 |                     | w:NA         |                     |
|                                  | /w:NA    |      | /w:NA    |                     | /w:NA            |                     | /w:NA            |                     | /w:NA    |                     | /w:NA    |                             | /w:NA                |                     | /w:NA        |                     |
| ep3                              | go:NA    |      | go:NA    |                     | go:t1            |                     | go:NA            |                     | go:t1    |                     | go:NA    |                             | go:NA                |                     | go:t1        |                     |
|                                  | w:NA     |      | w:NA     |                     | w:NA             |                     | w:NA             |                     | w:NA     |                     | w:NA     |                             | w:NA                 |                     | w:NA         |                     |
|                                  | /w:NA    |      | /w:NA    |                     | /w:NA            |                     | /w:NA            |                     | /w:NA    |                     | /w:NA    |                             | /w:NA                |                     | /w:NA        |                     |

|        | occ1ltx2<br>occ1 |                             | ltx1occ1<br>ltx1occ1 |                     | ltx2occ2 |                             | occ1ltx3 |                             | ltx1occ1ltx2 |                             | ltx2occ1ltx1 |                             | ltx3occ1    |                             | ltx4        |                                     |
|--------|------------------|-----------------------------|----------------------|---------------------|----------|-----------------------------|----------|-----------------------------|--------------|-----------------------------|--------------|-----------------------------|-------------|-----------------------------|-------------|-------------------------------------|
| t1     | OCC              | a:t4                        | LTX                  | <sup>c</sup><br>bd1 | LTX      | <sup>c</sup><br>bd1         | OCC      | a:t4                        | LTX          | <sup>c</sup><br>bd1         | LTX          | <sup>c</sup><br>bd1         | LTX         | <sup>c</sup><br>bd1         | LTX         | <sup>c</sup><br>bd1                 |
| t2     | LTX              | <sup>c</sup><br>bd2         | OCC                  | a:t1                | LTX      | <sup>c</sup><br>bd1<br>r:t1 | LTX      | <sup>c</sup><br>bd2         | OCC          | a:t1                        | LTX          | <sup>c</sup><br>bd1<br>r:t1 | LTX         | <sup>c</sup><br>bd1<br>r:t1 | LTX         | <sup>c</sup><br>bd1<br>r:t1         |
| t3     | LTX              | <sup>c</sup><br>bd2<br>r:t2 | LTX                  | <sup>c</sup><br>bd3 | OCC      | a:t2                        | LTX      | <sup>c</sup><br>bd2<br>r:t2 | LTX          | <sup>c</sup><br>bd3         | OCC          | a:t2                        | LTX         | <sup>c</sup><br>bd1<br>r:t2 | LTX         | <sup>c</sup><br>bd1<br>r:t2         |
| t4     | OCC              | a:t3                        | OCC                  | a:t3                | OCC      | c                           | LTX      | <sup>c</sup><br>bd2<br>r:t3 | LTX          | <sup>c</sup><br>bd3<br>r:t3 | LTX          | <sup>c</sup><br>bd4         | OCC         | a:t3                        | LTX         | <sup>a</sup><br>bd1<br>r:t2<br>w:t1 |
| read b | t2               |                             | t3                   |                     | t4       |                             | t2       |                             | t3           |                             | t4           |                             | t1          |                             | t1          |                                     |
| ep1    | go:t2/t3         |                             | go:t1/t3             |                     | go:t1/t2 |                             | go:t2/t3 |                             | go:t1/t3     |                             | go:t1/t2     |                             | go:t1/t2/t3 |                             | go:t1/t2/t3 |                                     |
|        | w:NA             |                             | w:NA                 |                     | w:NA     |                             | w:t4     |                             | w:t4         |                             | w:NA         |                             | w:NA        |                             | w:t4        |                                     |
|        | /w:NA            |                             | /w:NA                |                     | /w:NA    |                             | /w:t3    |                             | /w:t3        |                             | /w:NA        |                             | /w:NA       |                             | /w:t3       |                                     |
| ep2    | go:t2            |                             | go:t1                |                     | go:t1/t2 |                             | go:t2    |                             | go:t1        |                             | go:t1/t2     |                             | go:t1/t2    |                             | go:t1/t2    |                                     |
|        | w:t3             |                             | w:NA                 |                     | w:NA     |                             | w:t3/t4  |                             | w:NA         |                             | w:NA         |                             | w:t3        |                             | w:t3/t4     |                                     |
|        | /w:t2            |                             | /w:NA                |                     | /w:NA    |                             | /w:t3/t2 |                             | /w:NA        |                             | /w:NA        |                             | /w:t2       |                             | /w:t2/t3    |                                     |
| ep3    | go:NA            |                             | go:t1                |                     | go:t1    |                             | go:NA    |                             | go:t1        |                             | go:t1        |                             | go:t1       |                             | go:t1       |                                     |
|        | w:NA             |                             | w:NA                 |                     | w:t2     |                             | w:NA     |                             | w:NA         |                             | w:t2         |                             | w:t2/t3     |                             | w:t2/t3/t4  |                                     |
|        | /w:NA            |                             | /w:NA                |                     | /w:t1    |                             | /w:NA    |                             | /w:NA        |                             | /w:t1        |                             | /w:t1/t2    |                             | /w:t1/t2/t3 |                                     |

Write Crown  
overlapped\_all\_4tx

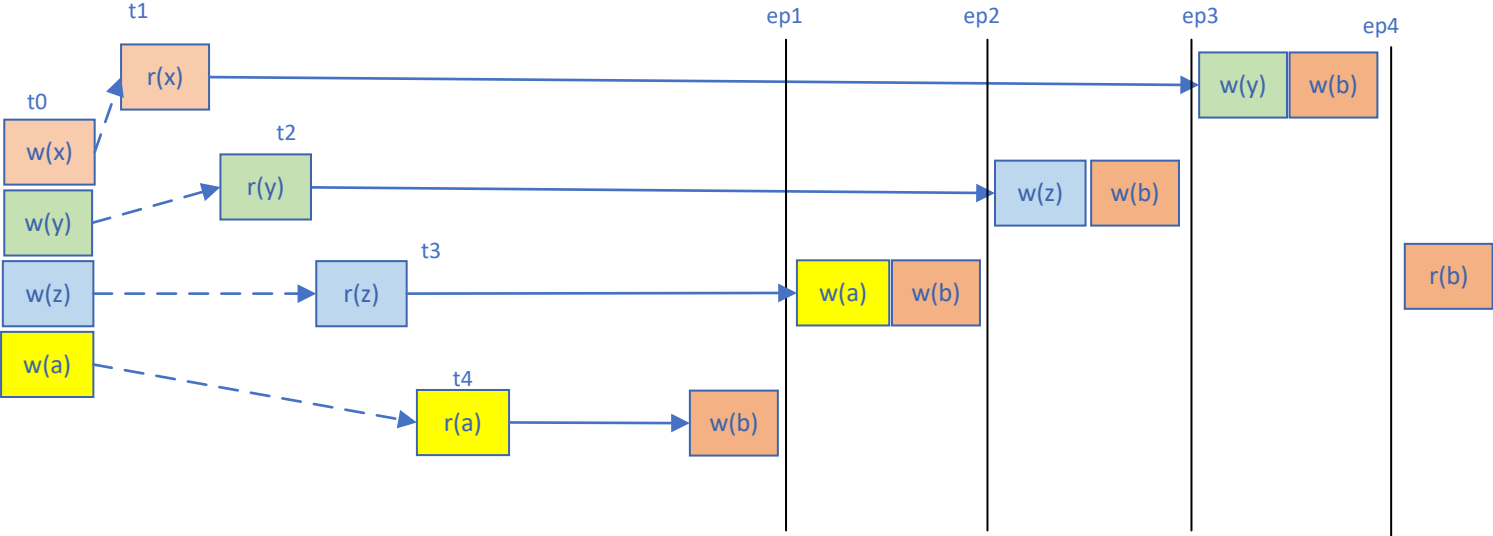
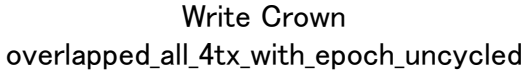


| write_crown             |      |   |          |                     |                  |                     |                  |                     |          |                     |          |                             |                      |                     |              |                     |
|-------------------------|------|---|----------|---------------------|------------------|---------------------|------------------|---------------------|----------|---------------------|----------|-----------------------------|----------------------|---------------------|--------------|---------------------|
| overlapped_4tx_uncycled |      |   |          |                     |                  |                     |                  |                     |          |                     |          |                             |                      |                     |              |                     |
|                         | occ4 |   | occ3ltx1 |                     | occ2ltx1<br>occ1 |                     | occ1ltx1<br>occ2 |                     | ltx1occ3 |                     | occ2ltx2 |                             | occ1ltx1<br>occ1ltx1 |                     | ltx1occ2ltx1 |                     |
| t1                      | OCC  | c | OCC      | c                   | OCC              | c                   | OCC              | c                   | LTX      | <sup>c</sup><br>bd1 | OCC      | c                           | OCC                  | a:t4                | LTX          | <sup>c</sup><br>bd1 |
| t2                      | OCC  | c | OCC      | c                   | OCC              | c                   | LTX              | <sup>c</sup><br>bd2 | OCC      | a:t1                | OCC      | c                           | LTX                  | <sup>c</sup><br>bd2 | OCC          | a:t1                |
| t3                      | OCC  | c | OCC      | c                   | LTX              | <sup>c</sup><br>bd3 | OCC              | a:t2                | OCC      | c                   | LTX      | <sup>c</sup><br>bd3         | OCC                  | a:t2                | OCC          | c                   |
| t4                      | OCC  | c | LTX      | <sup>c</sup><br>bd4 | OCC              | a:t3                | OCC              | c                   | OCC      | c                   | LTX      | <sup>c</sup><br>bd3<br>r:t3 | LTX                  | <sup>c</sup><br>bd4 | LTX          | <sup>c</sup><br>bd4 |
| read b                  | t1   |   | t1       |                     | t1               |                     | t1               |                     | t3       |                     | t1       |                             | t4                   |                     | t3           |                     |

|        | occ1ltx2<br>occ1 |                             | ltx1occ1<br>ltx1occ1 |                     | ltx2occ2 |                             | occ1ltx3 |                             | ltx1occ1ltx2 |                             | ltx2occ1ltx1 |                             | ltx3occ1 |                             | ltx4 |                             |
|--------|------------------|-----------------------------|----------------------|---------------------|----------|-----------------------------|----------|-----------------------------|--------------|-----------------------------|--------------|-----------------------------|----------|-----------------------------|------|-----------------------------|
| t1     | OCC              | c                           | LTX                  | <sup>c</sup><br>bd1 | LTX      | <sup>c</sup><br>bd1         | OCC      | c                           | LTX          | <sup>c</sup><br>bd1         | LTX          | <sup>c</sup><br>bd1         | LTX      | <sup>c</sup><br>bd1         | LTX  | <sup>c</sup><br>bd1         |
| t2     | LTX              | <sup>c</sup><br>bd2         | OCC                  | a:t1                | LTX      | <sup>c</sup><br>bd1<br>r:t1 | LTX      | <sup>c</sup><br>bd2         | OCC          | a:t1                        | LTX          | <sup>c</sup><br>bd1<br>r:t1 | LTX      | <sup>c</sup><br>bd1<br>r:t1 | LTX  | <sup>c</sup><br>bd1<br>r:t1 |
| t3     | LTX              | <sup>c</sup><br>bd2<br>r:t2 | LTX                  | <sup>c</sup><br>bd3 | OCC      | a:t2                        | LTX      | <sup>c</sup><br>bd2<br>r:t2 | LTX          | <sup>c</sup><br>bd3         | OCC          | a:t2                        | LTX      | <sup>c</sup><br>bd1<br>r:t2 | LTX  | <sup>c</sup><br>bd1<br>r:t2 |
| t4     | OCC              | a:t3                        | OCC                  | a:t3                | OCC      | c                           | LTX      | <sup>c</sup><br>bd2<br>r:t3 | LTX          | <sup>c</sup><br>bd3<br>r:t3 | LTX          | <sup>c</sup><br>bd4         | OCC      | a:t3                        | LTX  | <sup>c</sup><br>bd1<br>r:t2 |
| read b | t1               |                             | t1 or t3             |                     | t4       |                             | t1       |                             | t1 or t3     |                             | t1 or t4     |                             | t1       |                             | t1   |                             |

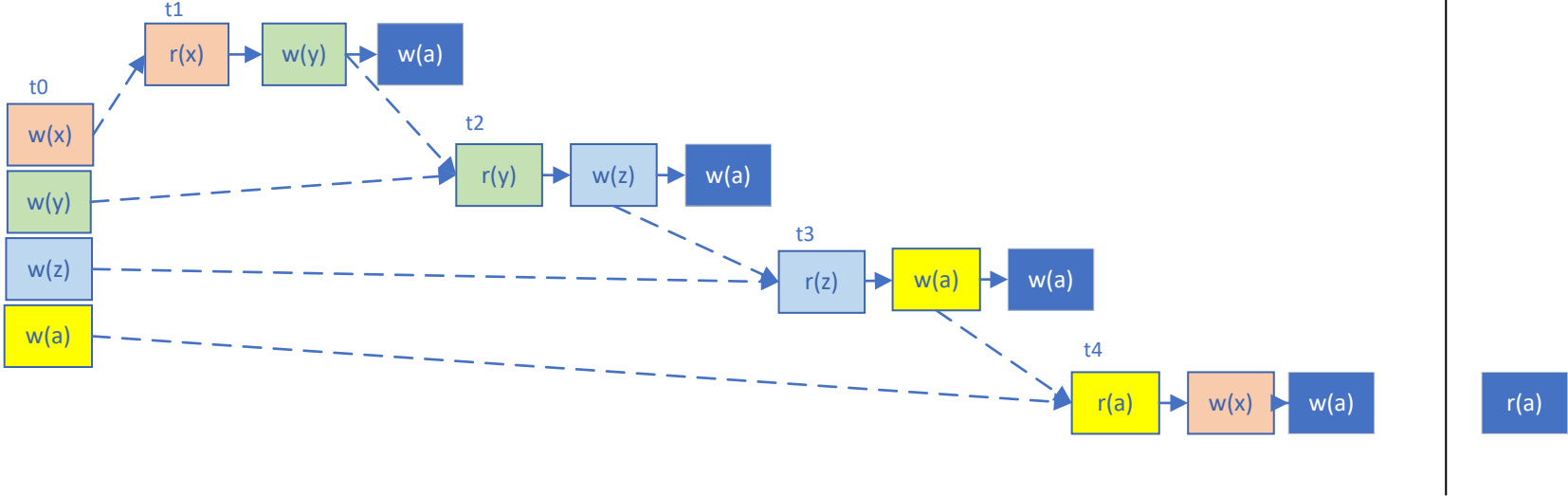
on going tx = go  
waiting tx = w  
waited tx = /w

OCCはできるだけ  
early abortさせている

[illegible]

|        |             | occ1ltx2<br>occ1           |          | ltx1occ1<br>ltx1occ1 |          | ltx2occ2                   |             | occ1ltx3                   |          | ltx1occ1ltx2               |          | ltx2occ1ltx1               |             | ltx3occ1                   |             | ltx4                       |  |
|--------|-------------|----------------------------|----------|----------------------|----------|----------------------------|-------------|----------------------------|----------|----------------------------|----------|----------------------------|-------------|----------------------------|-------------|----------------------------|--|
| t1     | OCC         | c                          | LTX      | <sup>c</sup><br>bd1  | LTX      | <sup>c</sup><br>bd1        | OCC         | c                          | LTX      | <sup>c</sup><br>bd1        | LTX      | <sup>c</sup><br>bd1        | LTX         | <sup>c</sup><br>bd1        | LTX         | <sup>c</sup><br>bd1        |  |
| t2     | LTX         | <sup>c</sup><br>bd2        | OCC      | at1                  | LTX      | <sup>c</sup><br>bd1<br>rt1 | LTX         | <sup>c</sup><br>bd2        | OCC      | at1                        | LTX      | <sup>c</sup><br>bd1<br>rt1 | LTX         | <sup>c</sup><br>bd1<br>rt1 | LTX         | <sup>c</sup><br>bd1<br>rt1 |  |
| t3     | LTX         | <sup>c</sup><br>bd2<br>rt2 | LTX      | <sup>c</sup><br>bd3  | OCC      | at2                        | LTX         | <sup>c</sup><br>bd2<br>rt2 | LTX      | <sup>c</sup><br>bd3        | OCC      | at2                        | LTX         | <sup>c</sup><br>bd1<br>rt2 | LTX         | <sup>c</sup><br>bd1<br>rt2 |  |
| t4     | OCC         | at3                        | OCC      | at3                  | OCC      | c                          | LTX         | <sup>c</sup><br>bd2<br>rt3 | LTX      | <sup>c</sup><br>bd3<br>rt3 | LTX      | <sup>c</sup><br>bd4        | OCC         | at3                        | LTX         | <sup>c</sup><br>bd1<br>rt2 |  |
| read b | t1          |                            | t3       |                      | t4       |                            | t1          |                            | t3       |                            | t4       |                            | t1          |                            | t1          |                            |  |
| ep1    | go:t1/t2/t3 |                            | go:t1/t3 |                      | go:t1/t2 |                            | go:t1/t2/t3 |                            | go:t1/t3 |                            | go:t1/t2 |                            | go:t1/t2/t3 |                            | go:t1/t2/t3 |                            |  |
|        | w:NA        |                            | w:NA     |                      | w:NA     |                            | w:t4        |                            | w:t4     |                            | w:NA     |                            | w:NA        |                            | w:t4        |                            |  |
|        | /w:NA       |                            | /w:NA    |                      | /w:NA    |                            | /w:t3       |                            | /w:t3    |                            | /w:NA    |                            | /w:NA       |                            | /w:t3       |                            |  |
| ep2    | go:t1/t2    |                            | go:t1    |                      | go:t1/t2 |                            | go:t1/t2    |                            | go:t1    |                            | go:t1/t2 |                            | go:t1/t2    |                            | go:t1/t2    |                            |  |
|        | w:t3        |                            | w:NA     |                      | w:NA     |                            | w:t3/t4     |                            | w:NA     |                            | w:NA     |                            | w:t3        |                            | w:t3/t4     |                            |  |
|        | /w:t2       |                            | /w:NA    |                      | /w:NA    |                            | /w:t2/t3    |                            | /w:NA    |                            | /w:NA    |                            | /w:t2       |                            | /w:t2/t3    |                            |  |
| ep3    | go:t1       |                            | go:t1    |                      | go:t1    |                            | go:t1       |                            | go:t1    |                            | go:t1    |                            | go:t1       |                            | go:t1       |                            |  |
|        | w:NA        |                            | w:NA     |                      | w:t2     |                            | w:NA        |                            | w:NA     |                            | w:t2     |                            | w:t2/t3     |                            | w:t2/t3/t4  |                            |  |
|        | /w:NA       |                            | /w:NA    |                      | /w:t1    |                            | /w:NA       |                            | /w:NA    |                            | /w:t1    |                            | /w:t1/t2    |                            | /w:t1/t2/t3 |                            |  |

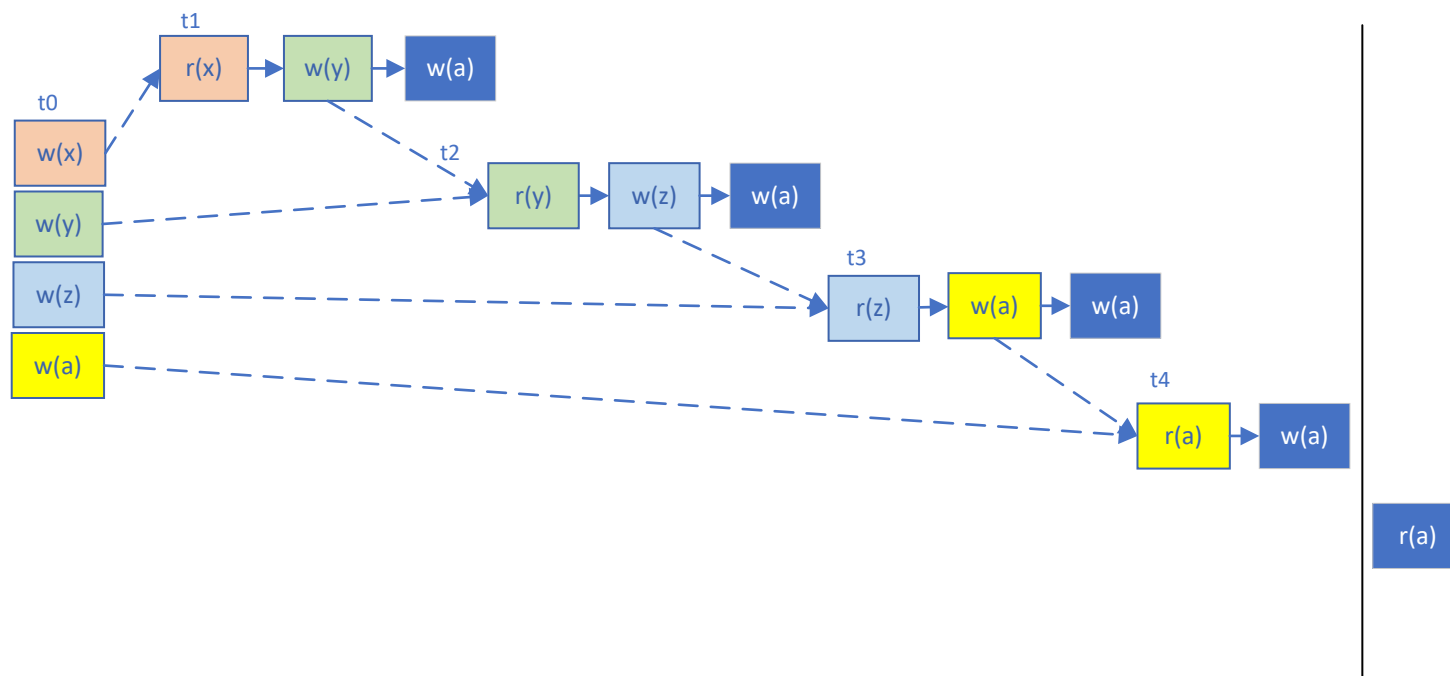
sequent\_4t\_cycled



| write_crown        |      |   |          |                     |                  |                                    |                  |                                    |          |                                    |          |                             |                      |                                    |              |                                    |
|--------------------|------|---|----------|---------------------|------------------|------------------------------------|------------------|------------------------------------|----------|------------------------------------|----------|-----------------------------|----------------------|------------------------------------|--------------|------------------------------------|
| sequent_4tx_cycled |      |   |          |                     |                  |                                    |                  |                                    |          |                                    |          |                             |                      |                                    |              |                                    |
|                    | occ4 |   | occ3ltx1 |                     | occ2ltx1<br>occ1 |                                    | occ1ltx1<br>occ2 |                                    | ltx1occ3 |                                    | occ2ltx2 |                             | occ1ltx1<br>occ1ltx1 |                                    | ltx1occ2ltx1 |                                    |
| t1                 | OCC  | c | OCC      | a:t4                | OCC              | c                                  | OCC              | c                                  | LTX      | <sup>c</sup><br>bd1                | OCC      | a:t4                        | OCC                  | a:t4                               | LTX          | <sup>c</sup><br>bd1                |
| t2                 | OCC  | c | OCC      | c                   | OCC              | c                                  | LTX              | <sup>c</sup><br>bd2                | OCC      | <span style="color: red;">c</span> | OCC      | c                           | LTX                  | <sup>c</sup><br>bd2                | OCC          | <span style="color: red;">c</span> |
| t3                 | OCC  | c | OCC      | c                   | LTX              | <sup>c</sup><br>bd3                | OCC              | <span style="color: red;">c</span> | OCC      | c                                  | LTX      | <sup>c</sup><br>bd3         | OCC                  | <span style="color: red;">c</span> | OCC          | c                                  |
| t4                 | OCC  | c | LTX      | <sup>c</sup><br>bd4 | OCC              | <span style="color: red;">c</span> | OCC              | c                                  | OCC      | c                                  | LTX      | <sup>c</sup><br>bd3<br>r:t3 | LTX                  | <sup>c</sup><br>bd4                | LTX          | <sup>c</sup><br>bd4                |
| read b             | t4   |   | t3       |                     | t4               |                                    | t4               |                                    | t4       |                                    | t2       |                             | t3                   |                                    | t3           |                                    |

|        | occ1ltx2<br>occ1 |                             | ltx1occ1<br>ltx1occ1 |                     | ltx2occ2 |                                    | occ1ltx3 |                             | ltx1occ1ltx2 |                                    | ltx2occ1ltx1 |                                    | ltx3occ1 |                                    | ltx4 |                             |
|--------|------------------|-----------------------------|----------------------|---------------------|----------|------------------------------------|----------|-----------------------------|--------------|------------------------------------|--------------|------------------------------------|----------|------------------------------------|------|-----------------------------|
| t1     | OCC              | c                           | LTX                  | <sup>c</sup><br>bd1 | LTX      | <sup>c</sup><br>bd1                | OCC      | a:t4                        | LTX          | <sup>c</sup><br>bd1                | LTX          | <sup>c</sup><br>bd1                | LTX      | <sup>c</sup><br>bd1                | LTX  | <sup>c</sup><br>bd1         |
| t2     | LTX              | <sup>c</sup><br>bd2         | OCC                  | c                   | LTX      | <sup>c</sup><br>bd1<br>r:t1        | LTX      | <sup>c</sup><br>bd2         | OCC          | <span style="color: red;">c</span> | LTX          | <sup>c</sup><br>bd1<br>r:t1        | LTX      | <sup>c</sup><br>bd1<br>r:t1        | LTX  | <sup>c</sup><br>bd1<br>r:t1 |
| t3     | LTX              | <sup>c</sup><br>bd2<br>r:t2 | LTX                  | <sup>c</sup><br>bd3 | OCC      | <span style="color: red;">c</span> | LTX      | <sup>c</sup><br>bd2<br>r:t2 | LTX          | <sup>c</sup><br>bd3                | OCC          | <span style="color: red;">c</span> | LTX      | <sup>c</sup><br>bd1<br>r:t2        | LTX  | <sup>c</sup><br>bd1<br>r:t2 |
| t4     | OCC              | c                           | OCC                  | c                   | OCC      | c                                  | LTX      | <sup>c</sup><br>bd2<br>r:t3 | LTX          | <sup>c</sup><br>bd3<br>r:t3        | LTX          | <sup>c</sup><br>bd4                | OCC      | <span style="color: red;">c</span> | LTX  | a<br>bd1<br>r:t3<br>w:t1    |
| read b | t4               |                             | t4                   |                     | t4       |                                    | t2       |                             | t2           |                                    | t3           |                                    | t4       |                                    | t1   |                             |

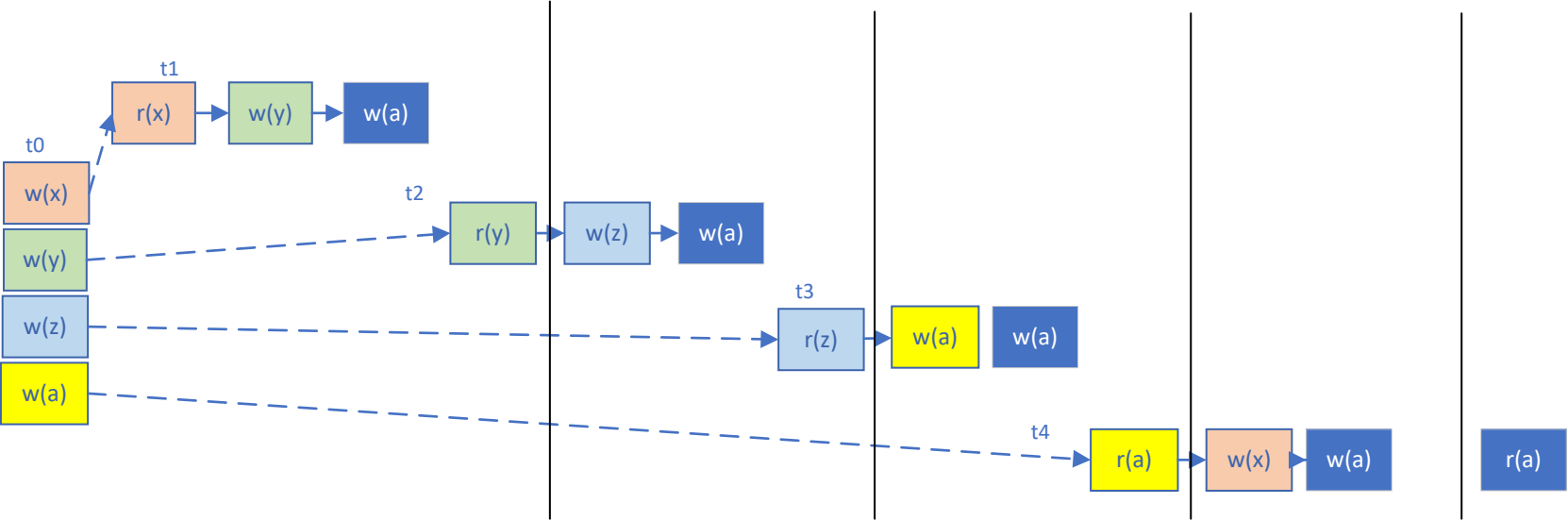
sequent\_4tx\_uncycled



| write_crown          |      |   |          |                     |                  |                                    |                  |                                    |          |                                    |          |                             |                      |                                    |              |                                    |
|----------------------|------|---|----------|---------------------|------------------|------------------------------------|------------------|------------------------------------|----------|------------------------------------|----------|-----------------------------|----------------------|------------------------------------|--------------|------------------------------------|
| sequent_4tx_uncycled |      |   |          |                     |                  |                                    |                  |                                    |          |                                    |          |                             |                      |                                    |              |                                    |
|                      | occ4 |   | occ3ltx1 |                     | occ2ltx1<br>occ1 |                                    | occ1ltx1<br>occ2 |                                    | ltx1occ3 |                                    | occ2ltx2 |                             | occ1ltx1<br>occ1ltx1 |                                    | ltx1occ2ltx1 |                                    |
| t1                   | OCC  | c | OCC      | c                   | OCC              | c                                  | OCC              | c                                  | LTX      | <sup>c</sup><br>bd1                | OCC      | c                           | OCC                  | c                                  | LTX          | <sup>c</sup><br>bd1                |
| t2                   | OCC  | c | OCC      | c                   | OCC              | c                                  | LTX              | <sup>c</sup><br>bd2                | OCC      | <span style="color: red;">c</span> | OCC      | c                           | LTX                  | <sup>c</sup><br>bd2                | OCC          | <span style="color: red;">c</span> |
| t3                   | OCC  | c | OCC      | c                   | LTX              | <sup>c</sup><br>bd3                | OCC              | <span style="color: red;">c</span> | OCC      | c                                  | LTX      | <sup>c</sup><br>bd3         | OCC                  | <span style="color: red;">c</span> | OCC          | c                                  |
| t4                   | OCC  | c | LTX      | <sup>c</sup><br>bd4 | OCC              | <span style="color: red;">c</span> | OCC              | c                                  | OCC      | c                                  | LTX      | <sup>c</sup><br>bd3<br>r:t3 | LTX                  | <sup>c</sup><br>bd4                | LTX          | <sup>c</sup><br>bd4                |
| read b               | t4   |   | t3       |                     | t4               |                                    | t4               |                                    | t4       |                                    | t2       |                             | t3                   |                                    | t3           |                                    |

|        | occ1ltx2<br>occ1 |                             | ltx1occ1<br>ltx1occ1 |                     | ltx2occ2 |                                    | occ1ltx3 |                             | ltx1occ1ltx2 |                                    | ltx2occ1ltx1 |                                    | ltx3occ1 |                                    | ltx4 |                             |
|--------|------------------|-----------------------------|----------------------|---------------------|----------|------------------------------------|----------|-----------------------------|--------------|------------------------------------|--------------|------------------------------------|----------|------------------------------------|------|-----------------------------|
| t1     | OCC              | c                           | LTX                  | <sup>c</sup><br>bd1 | LTX      | <sup>c</sup><br>bd1                | OCC      | c                           | LTX          | <sup>c</sup><br>bd1                | LTX          | <sup>c</sup><br>bd1                | LTX      | <sup>c</sup><br>bd1                | LTX  | <sup>c</sup><br>bd1         |
| t2     | LTX              | <sup>c</sup><br>bd2         | OCC                  | c                   | LTX      | <sup>c</sup><br>bd1<br>r:t1        | LTX      | <sup>c</sup><br>bd2         | OCC          | <span style="color: red;">c</span> | LTX          | <sup>c</sup><br>bd1<br>r:t1        | LTX      | <sup>c</sup><br>bd1<br>r:t1        | LTX  | <sup>c</sup><br>bd1<br>r:t1 |
| t3     | LTX              | <sup>c</sup><br>bd2<br>r:t2 | LTX                  | <sup>c</sup><br>bd3 | OCC      | <span style="color: red;">c</span> | LTX      | <sup>c</sup><br>bd2<br>r:t2 | LTX          | <sup>c</sup><br>bd3                | OCC          | <span style="color: red;">c</span> | LTX      | <sup>c</sup><br>bd1<br>r:t2        | LTX  | <sup>c</sup><br>bd1<br>r:t2 |
| t4     | OCC              | c                           | OCC                  | c                   | OCC      | c                                  | LTX      | <sup>c</sup><br>bd2<br>r:t3 | LTX          | <sup>c</sup><br>bd3<br>r:t3        | LTX          | <sup>c</sup><br>bd4                | OCC      | <span style="color: red;">c</span> | LTX  | <sup>c</sup><br>bd1<br>r:t3 |
| read b | t4               |                             | t4                   |                     | t4       |                                    | t1       |                             | t2           |                                    | t3           |                                    | t4       |                                    | t1   |                             |

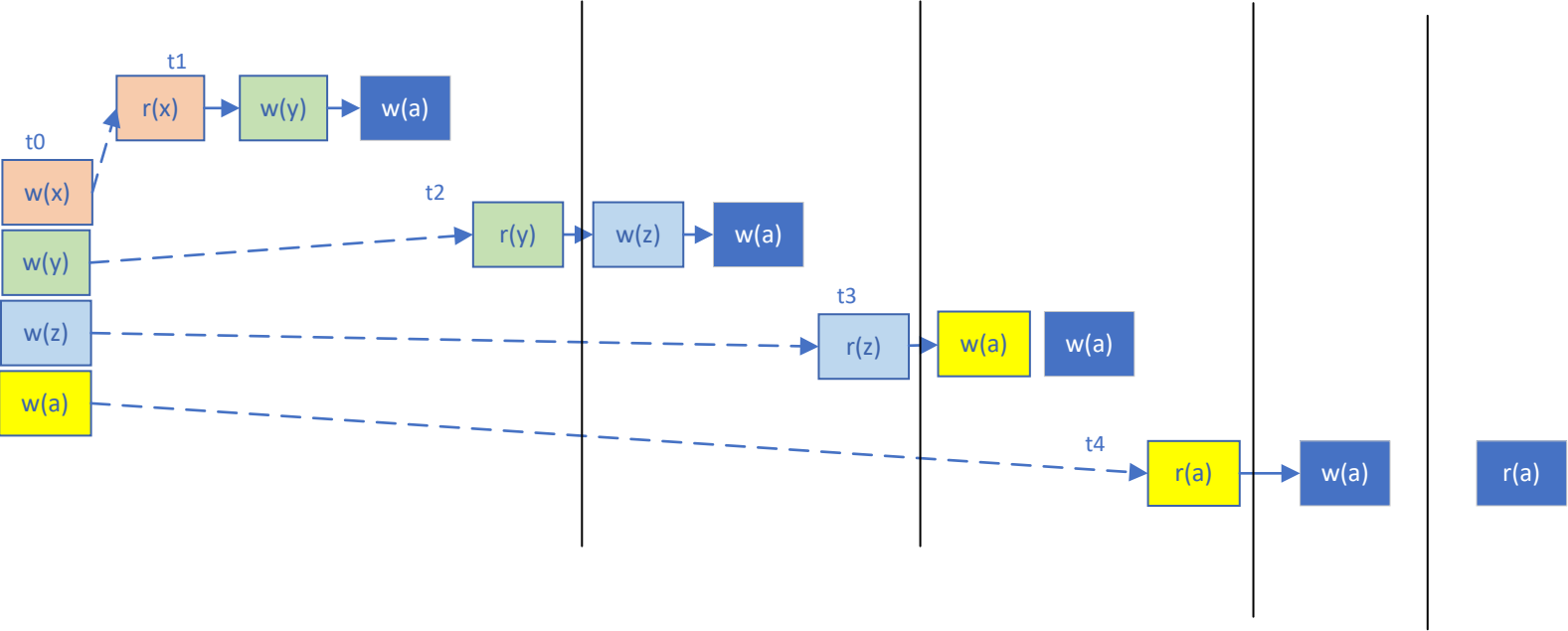
sequent\_4tx\_with\_epoch



|                               |
|-------------------------------|
| write_crown                   |
| sequent_4tx_with_epoch_cycled |

|        | occ1<br>ltx3 |                         | ltx4 |                         |
|--------|--------------|-------------------------|------|-------------------------|
| t1     | OCC          | c                       | LTX  | c<br>bd:1               |
| t2     | LTX          | c<br>bd:2               | LTX  | c<br>bd:1<br>rt1        |
| t3     | LTX          | c<br>bd:2<br>rt2        | LTX  | c<br>bd:1<br>rt2        |
| t4     | LTX          | a<br>bd:2<br>rt3<br>wt1 | LTX  | a<br>bd:1<br>rt3<br>wt1 |
| read b | t1           |                         | t1   |                         |





|                                 |
|---------------------------------|
| write_crown                     |
| sequent_4tx_with_epoch_uncycled |

|        | occ1<br>ltx3 |                   | ltx4 |                   |
|--------|--------------|-------------------|------|-------------------|
| t1     | OCC          | c                 | LTX  | c<br>bd:1         |
| t2     | LTX          | c<br>bd:2         | LTX  | c<br>bd:1<br>r:t1 |
| t3     | LTX          | c<br>bd:2<br>r:t2 | LTX  | c<br>bd:1<br>r:t2 |
| t4     | LTX          | c<br>bd:2<br>r:t3 | LTX  | c<br>bd:1<br>r:t3 |
| read b | t1           |                   | t1   |                   |