Compiling CSP

or having fun with a new occam-π compiler and CSP

(and fringe presentation)

Fred Barnes, Systems Research Group
Computing Laboratory, University of Kent, UK
F.R.M.Barnes@kent.ac.uk

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  - CSP itself primarily used for **formal modelling**
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  - e.g. with tools such as **KRoC/occam-π**, **JCSP**, **C++CSP**, **CTJ**, etc.
- This work is concerned with the **compilation** of CSP to executable code
  - so that we can experiment with interesting and complex systems :-)
  - including the **TUNA** project's models of platelet behaviour (investigating models of blood-clotting and, more generally, **nanite assemblers**)

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- A new occam-π compiler to replace the existing compiler in KRoC
  - the existing compiler is becoming increasing difficult to maintain
  - based on a fairly old (but industry proven) code base, mostly 1987
  - designed to run in 2 MB of memory, so quite compact/optimal in places
  - but was never really designed to handle the dynamics introduced by occam-π
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  - written in C, started off around 60,000 lines, now at around 120,000
- Currently around 55,000 lines of C code, named **NOCC**
  - maybe not the best language for implementing compilers ...
  - and do we really need another compiler ?
  - on the other hand, few compilers have low-level representations for parallelism (mostly in compilers for parallel hardware)

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  - good test of NOCC's ability to handle different source languages
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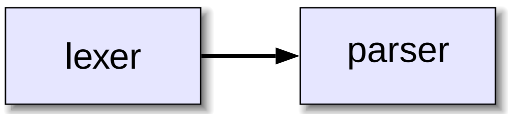

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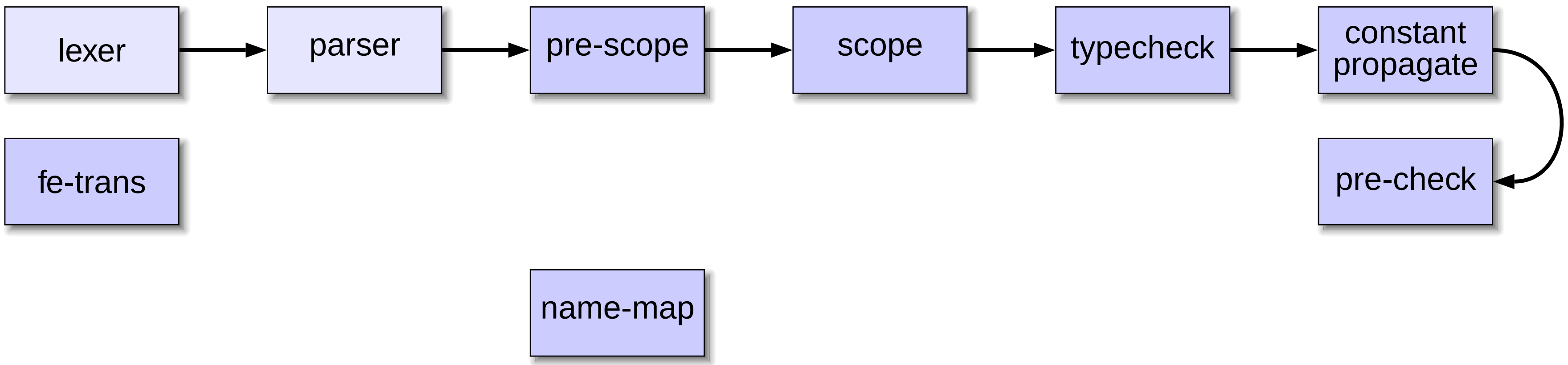

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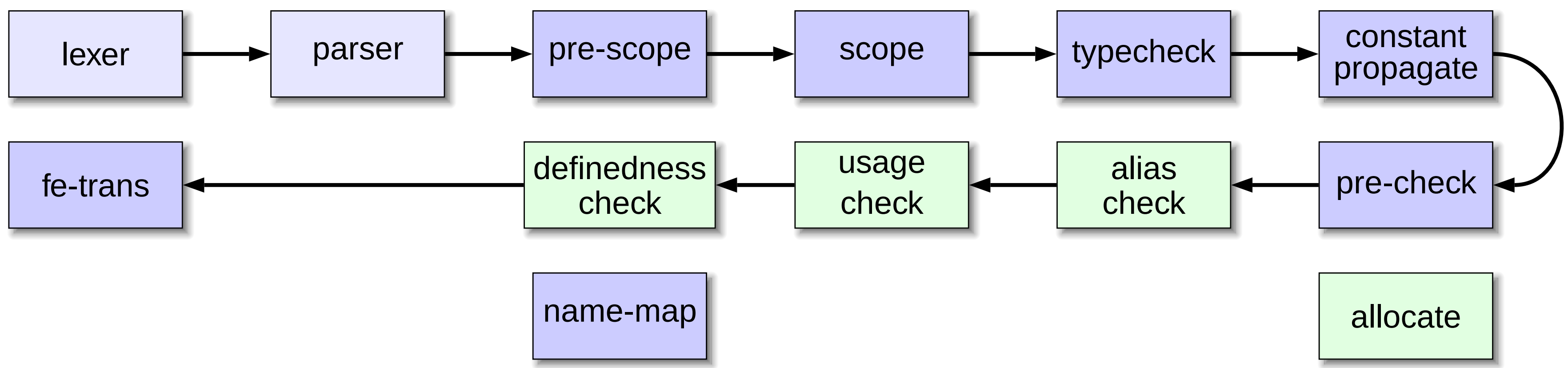

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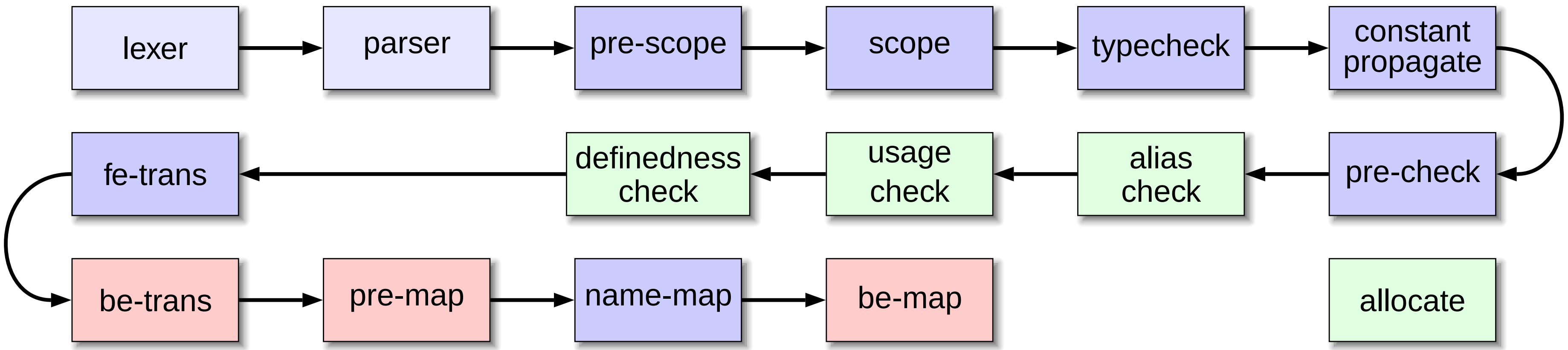

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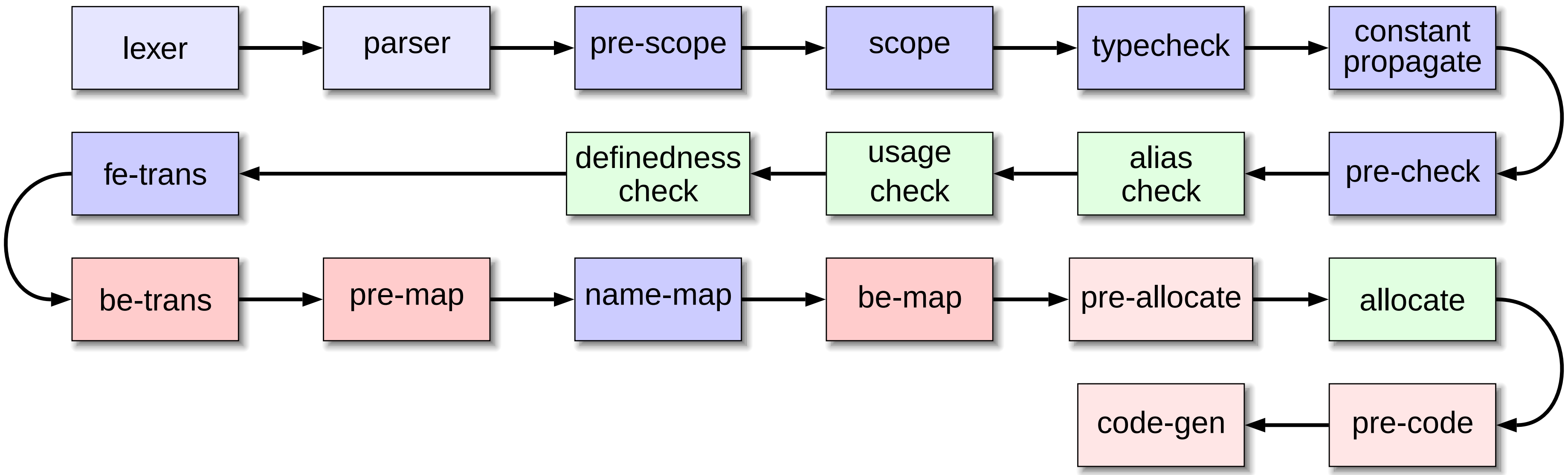

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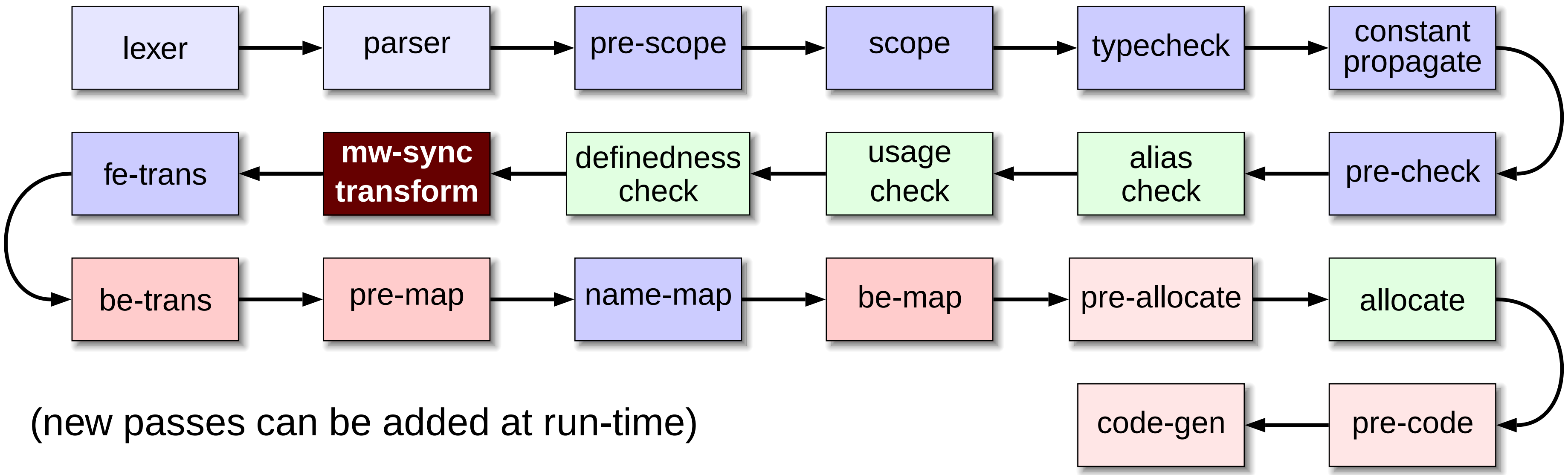

(new passes can be added at run-time)

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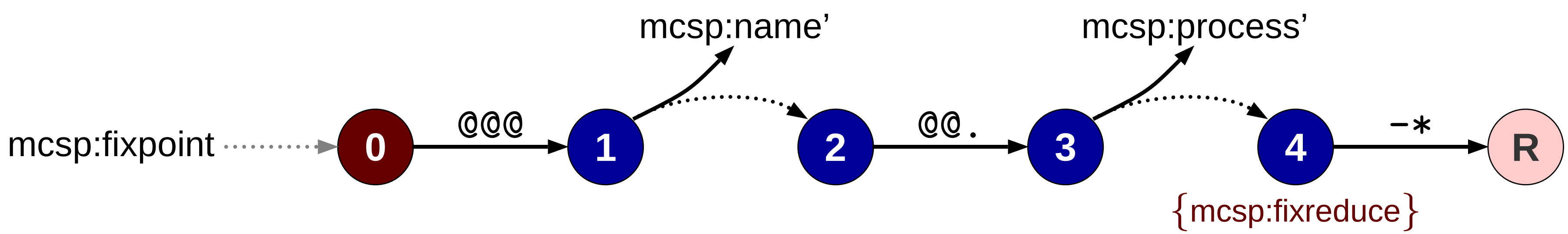

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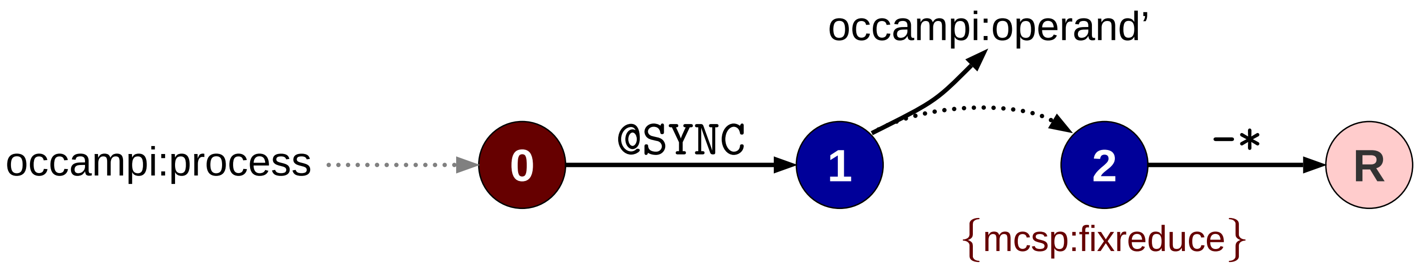

- Compiler collects up DFA chunks, in **tables** and merges
  - later resolution of **sub-parses** (branches out of the DFA)

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```
keyword "SYNC"
nodetype occampi:actionnode 3,0,0           # LHS, RHS, type
nodetag occampi:sync "occampi:actionnode"
reduce opi:syncreduce "SN0N+00C[occampi:sync]3R-"
dfarule occampi:process {
            0:  "@SYNC" -> 1
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```
# incase things weren't getting silly yet:
keyword "bnfrule"
nodetype nocc:bnfrulenode 2,0,0
nodetag nocc:bnfrule "nocc:bnfrulenode"
dfarule nocc:compilerdef {
         0:  "@bnfrule" -> 1
         1:  "+Name" -> 2
         2:  "+String" -> 3
         3:  "Newline" -> return
         3:  cfunc ("noccparser_bnfreduce")
}
```

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- Once all the DFAs are set up (choice may depend on language being parsed), language-specific code will parse input with, e.g.:

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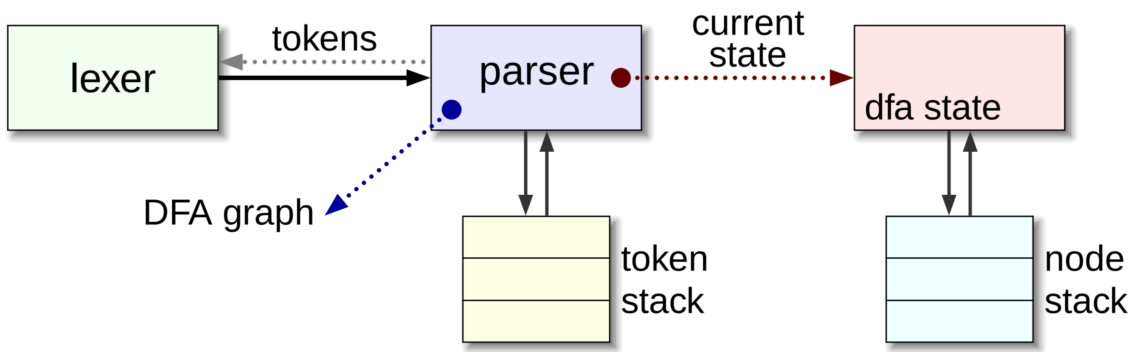

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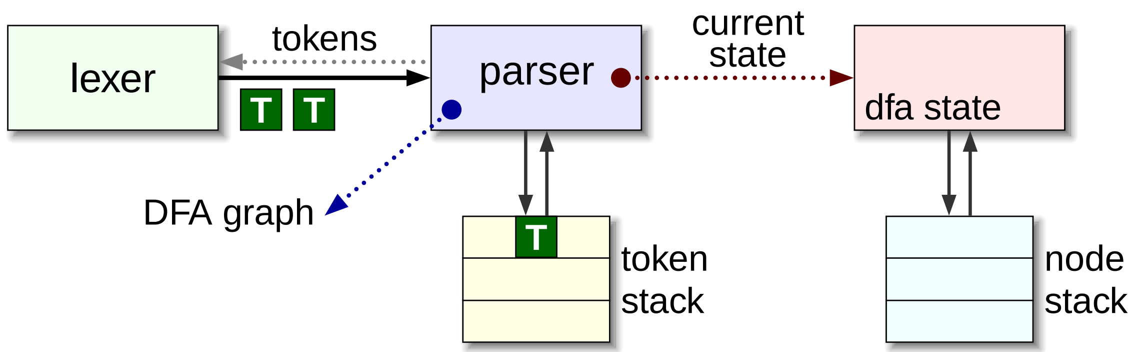

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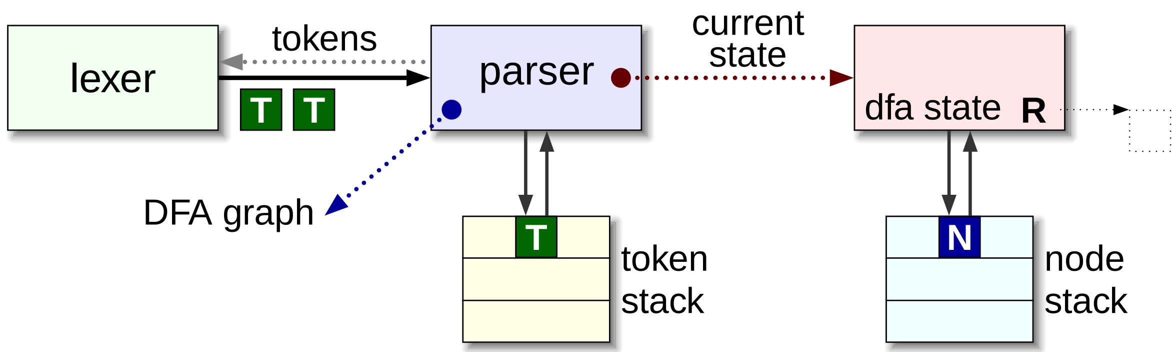

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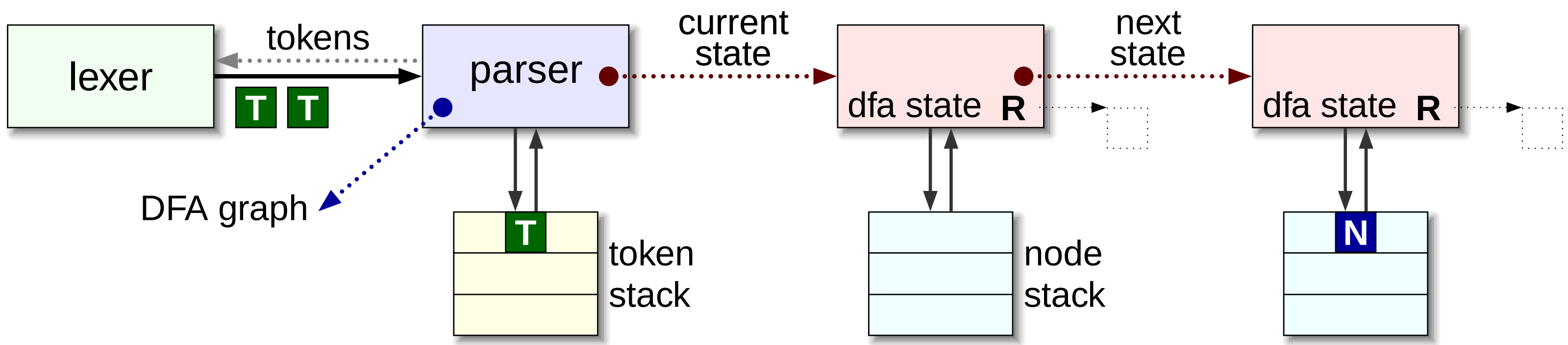

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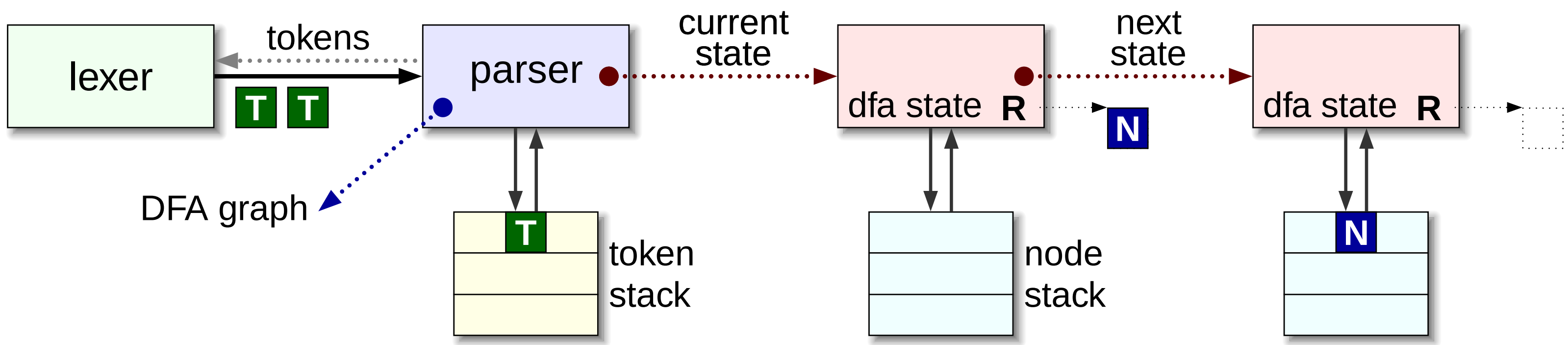

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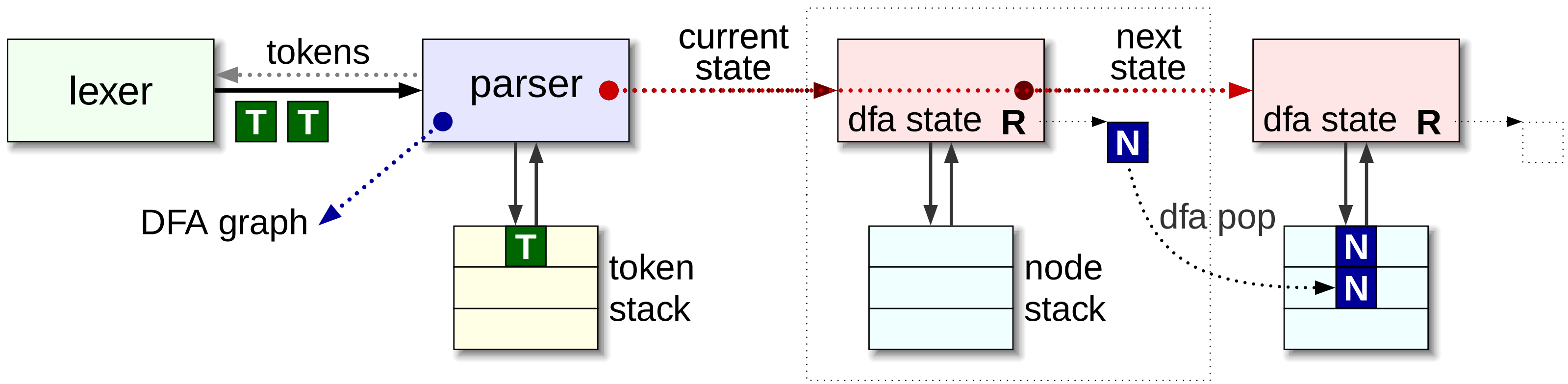

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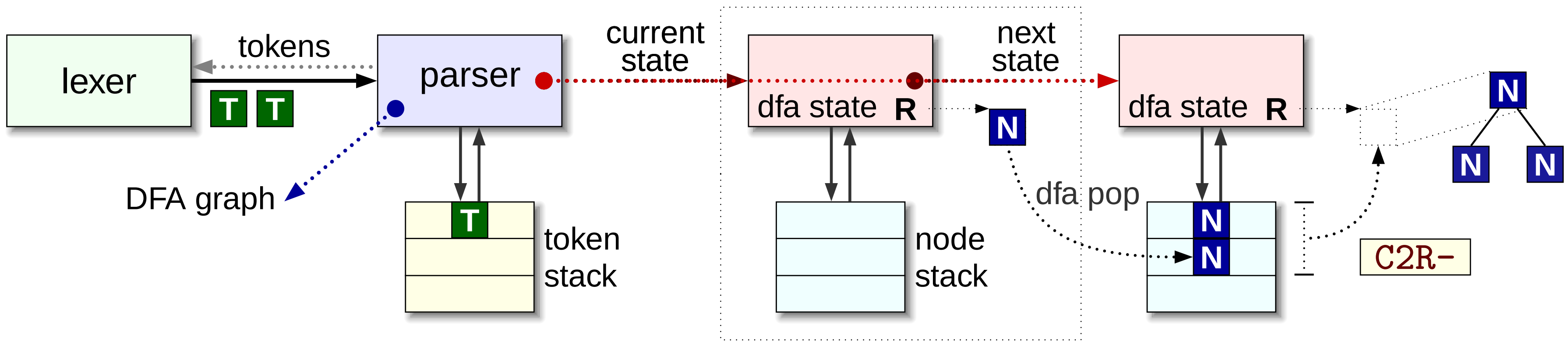

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- match 'FOO' keyword
- match assignment symbol
- match quoted string
- target state is the initial state of DFA rule 'bar'

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- Parser for a null language: `mylang ::= [ 0 * 0 ] [ 0 End ]`

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- Last interesting pass for most of a language front-end is **name-map**, which inserts back-end specific nodes into the tree

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	CSP	MCSP
skip	$SKIP$	`SKIP`
stop	$STOP$	`STOP`
chaos	$CHAOS$	`CHAOS`
divergence	div	`DIV`
event prefix	$e \longrightarrow P$	`e -> P`
internal choice	$(x \longrightarrow P) \sqcap (y \longrightarrow Q)$	`(x -> P) |~| (y -> Q)`
external choice	$(x \longrightarrow P) \Box (y \longrightarrow Q)$	`(x -> P) [] (y -> Q)`
sequence	$P \fatsemi Q$	`P; Q`
parallel	$P \parallel Q$	`P || Q`
interleaving	$P \mid\mid\mid Q$	`P ||| Q`
hiding	$P \setminus \{a\}$	`P \ {a}`
fixpoint	$\mu X.P$	`@X.P`

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Interleaving Multiway Synchronisations

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instead we could have written:

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  - also a small structure associated with each synchronising process
- In most cases will have up to two levels of synchronisation
  - synchronisation completed in one of the **sets**
  - synchronisation completed at the top-level

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barrier

procbar_t *parent	
int sets_enrolled	0
int sets_downcount	0
parbar_t *set_fptr	
parbar_t *set_bptr	

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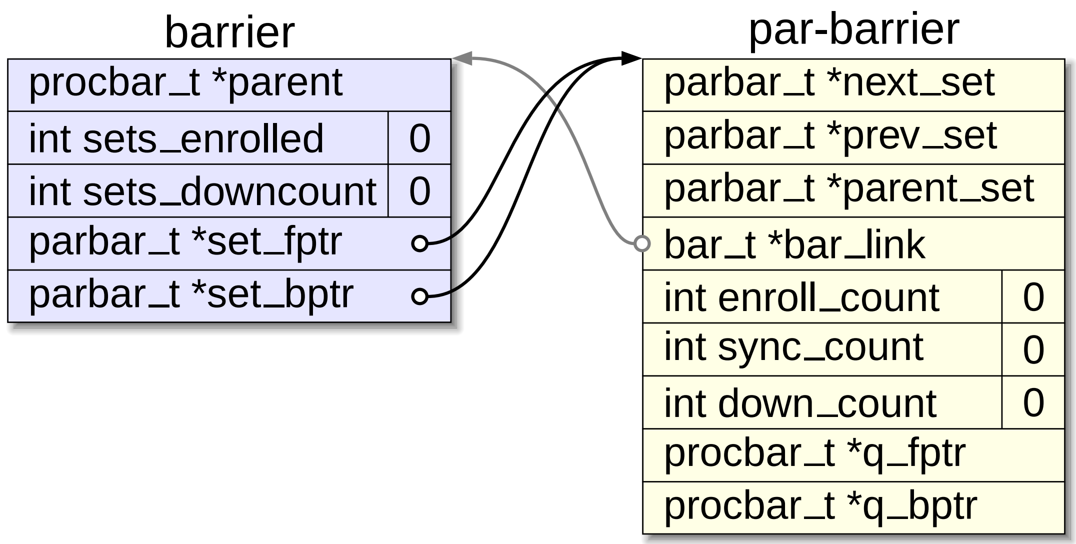

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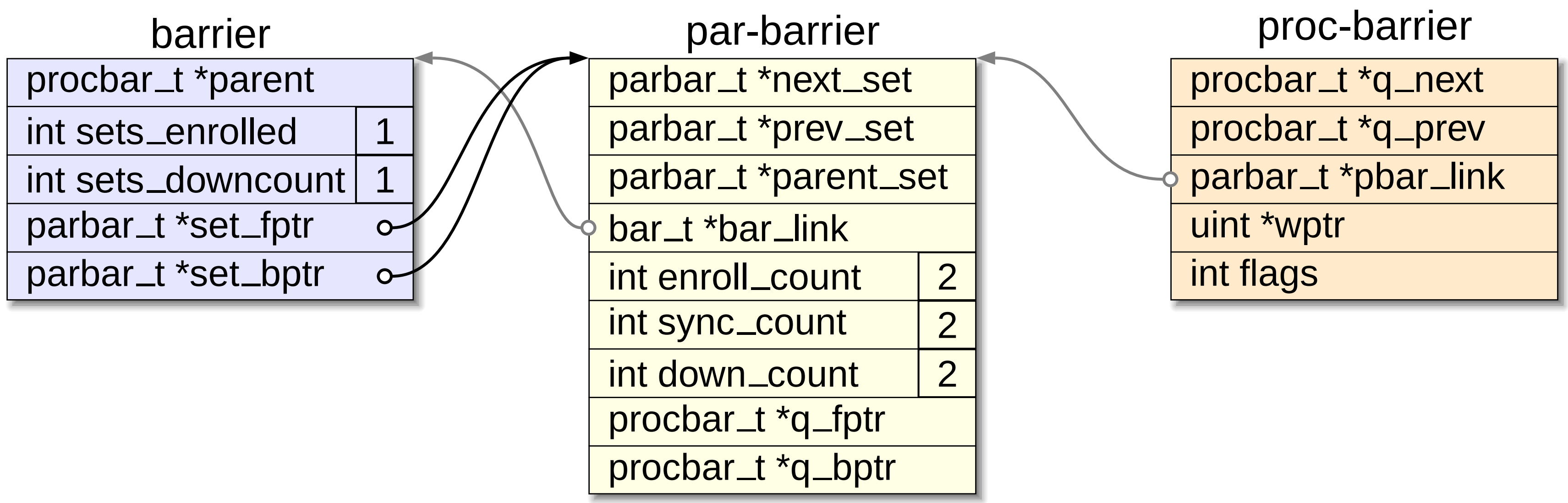

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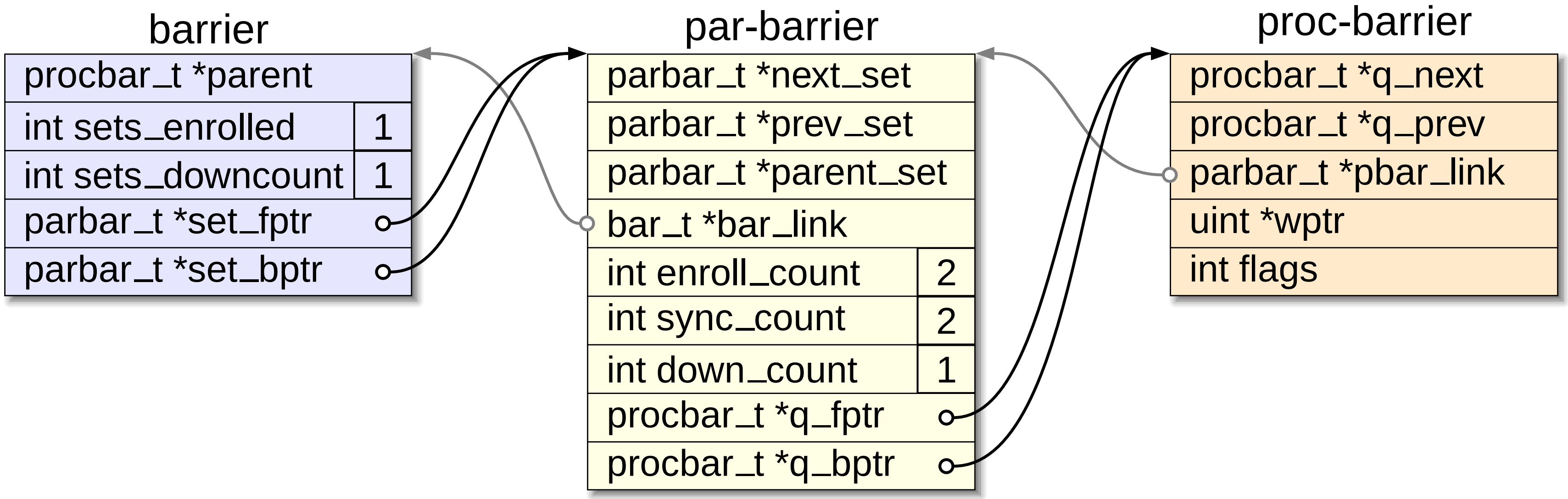

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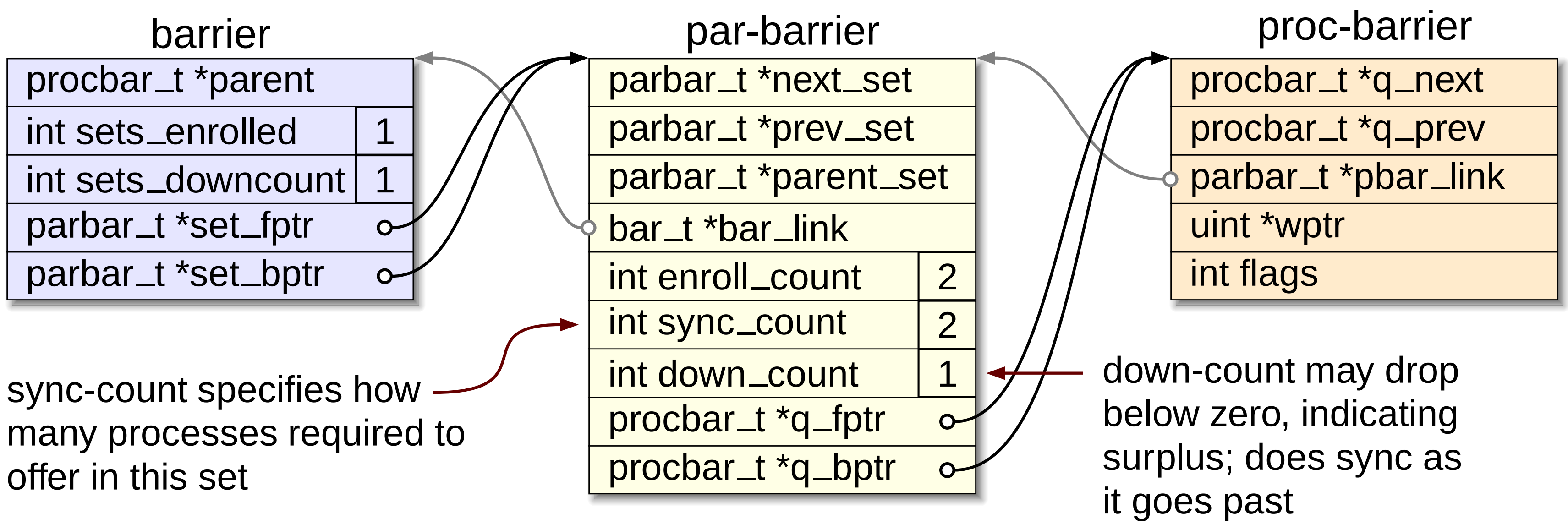

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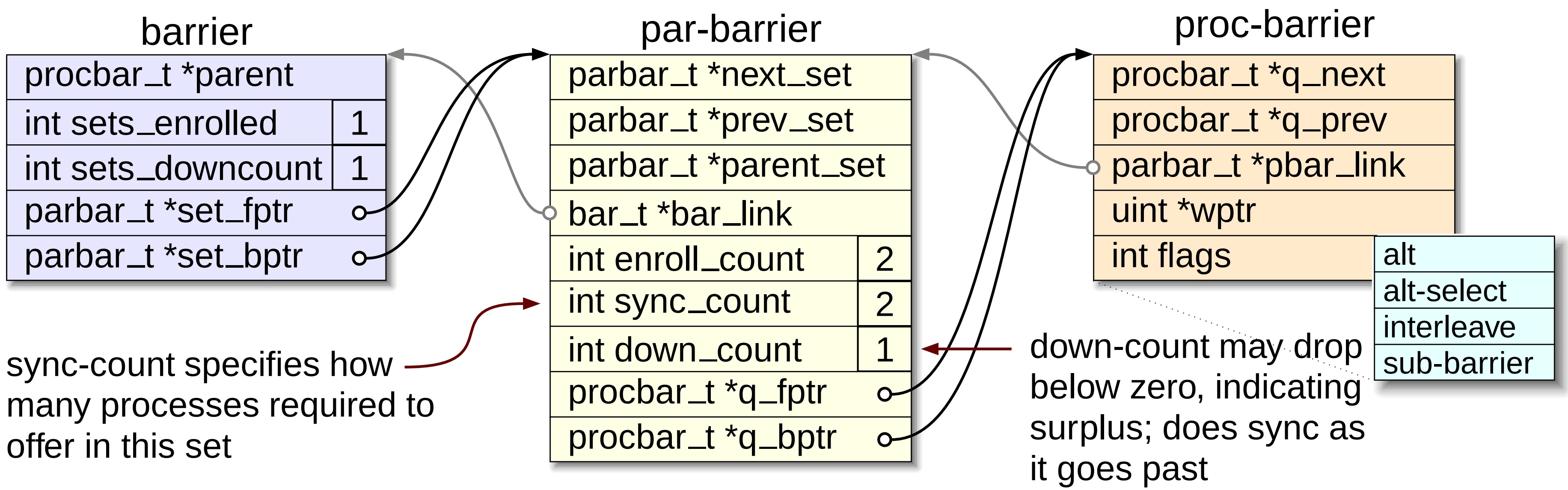

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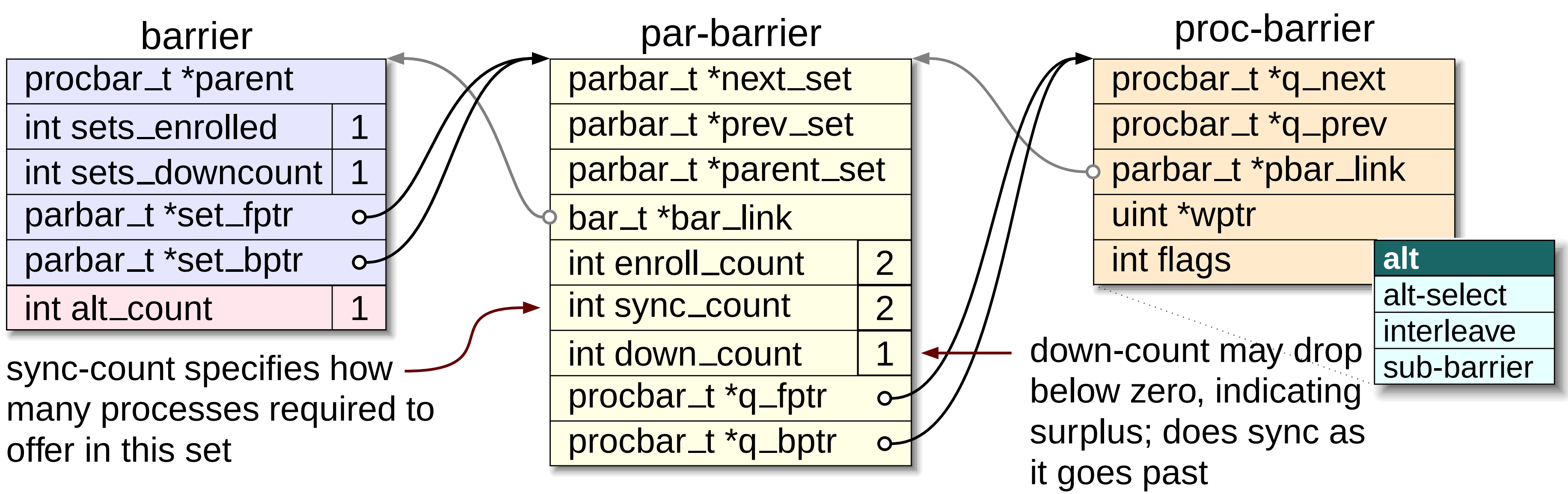

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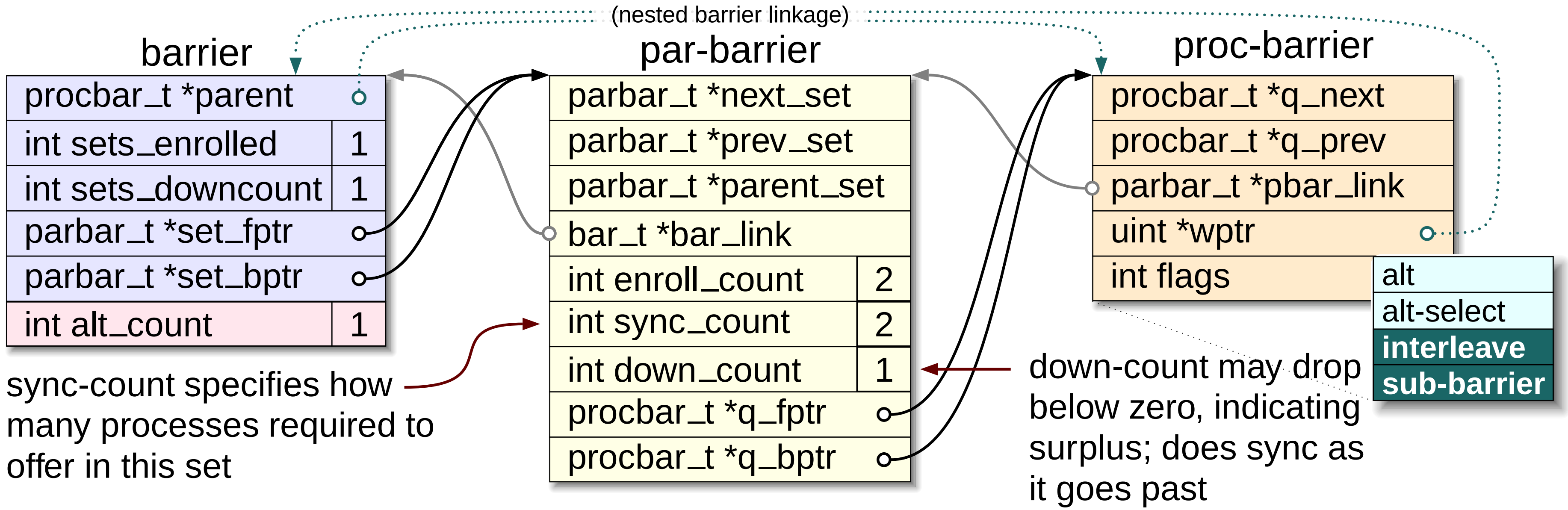

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- Certain cases of interleaving require nesting of these (or do they...)
  - only when interleaving processes go sub-parallel or sub-interleave

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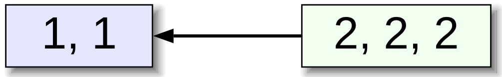

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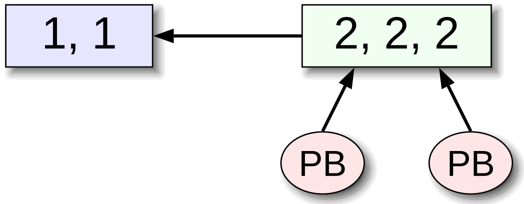

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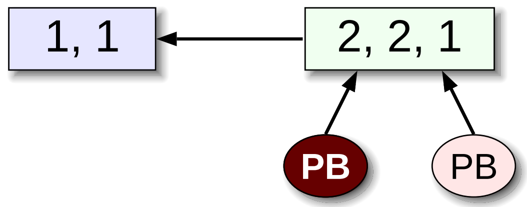

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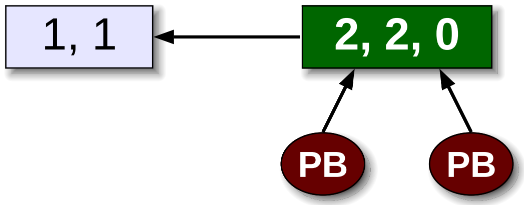

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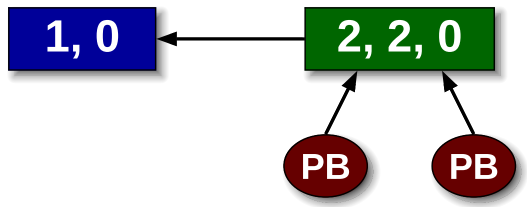

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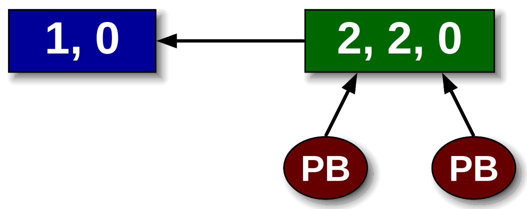

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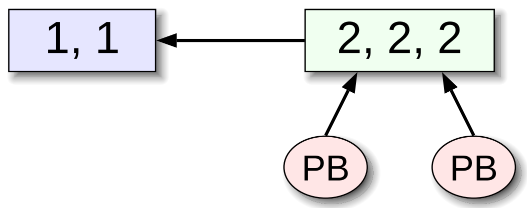

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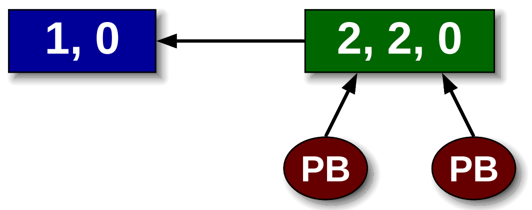

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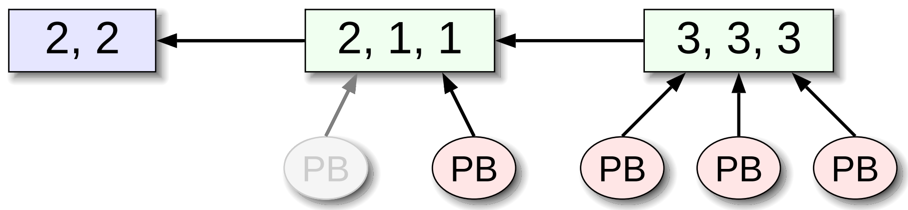

- Sub-parallelism (or interleaving) creates a logically upside-down tree; if P goes parallel with 3 sub-processes, its own is resigned

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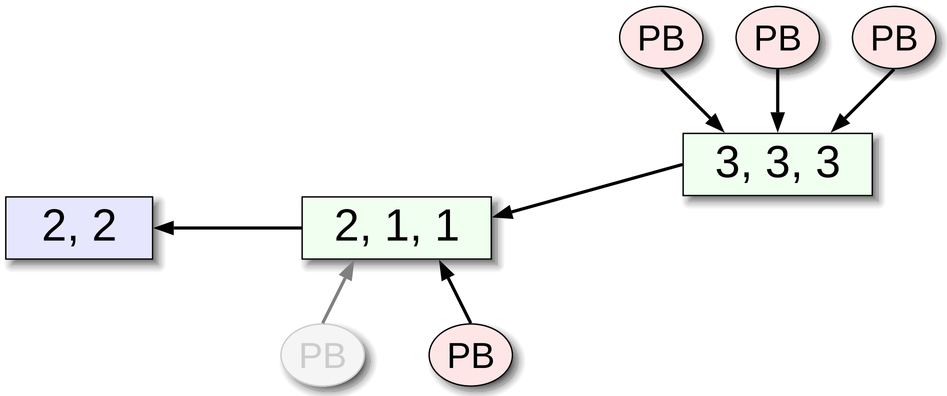
- If the other branch (Q) goes parallel simultaneously:



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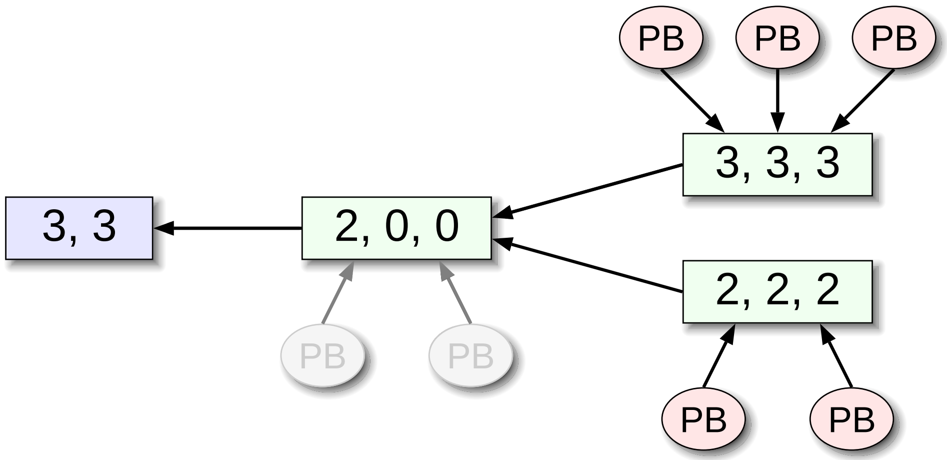

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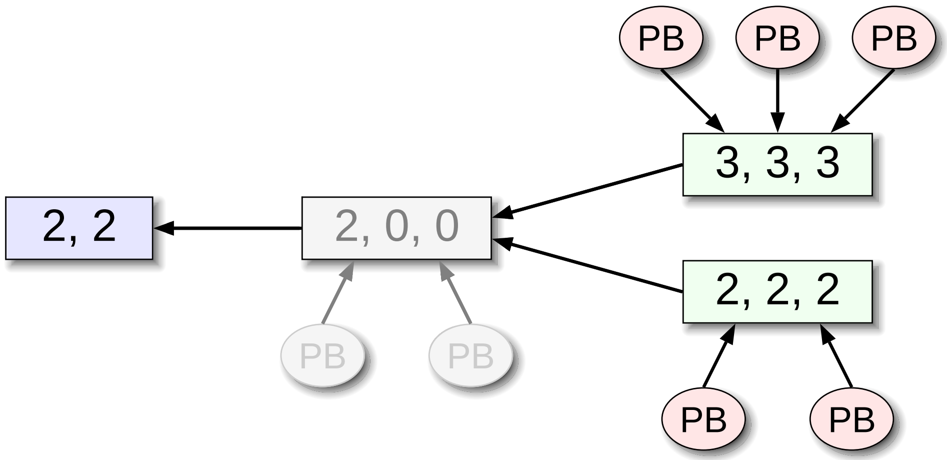

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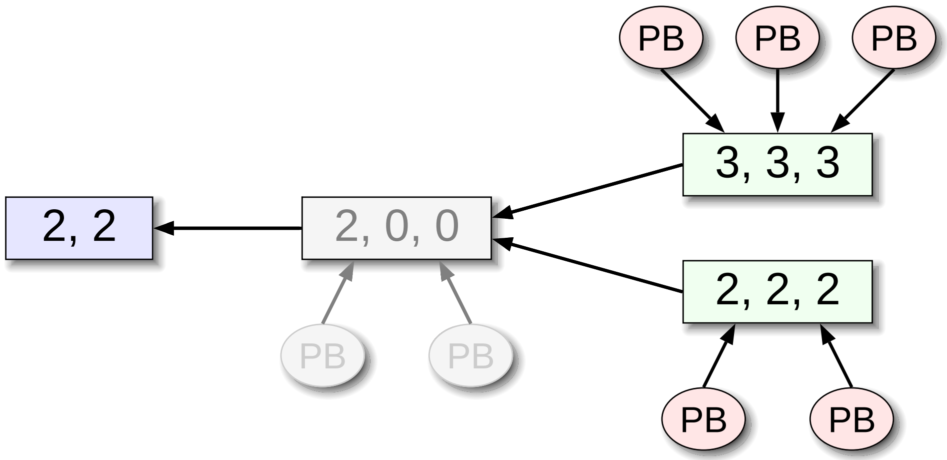

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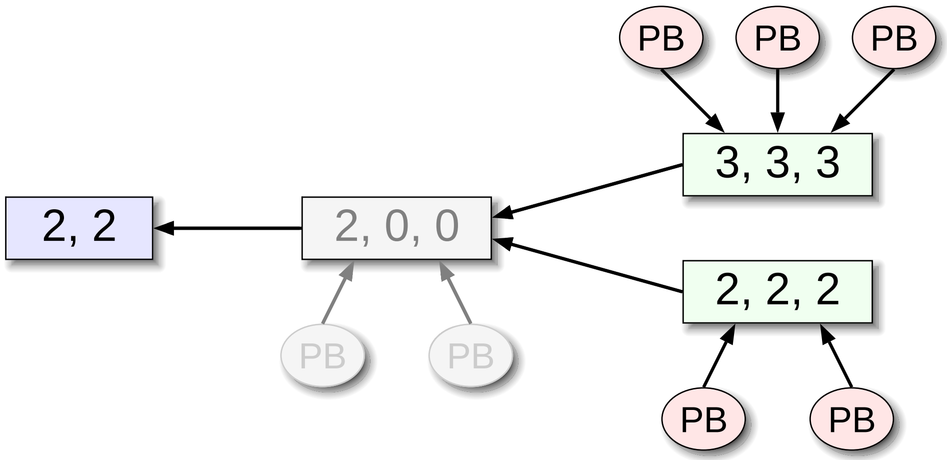

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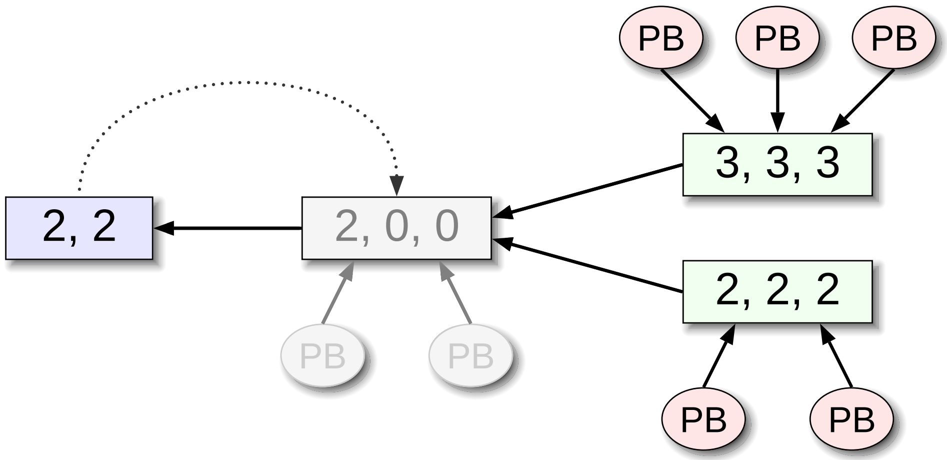

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- Implementation currently leaves the disabled set attached to the linked-list of sets, could remove it if we wanted ...

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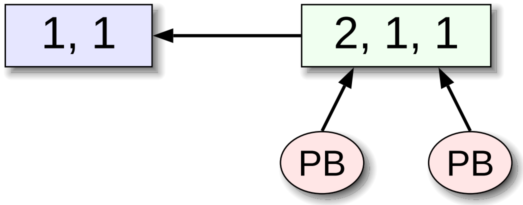
- Straight-forward interleaving (1-of-N) is handled by fixing the sync-count at 1:

```
(P (b) ||| Q (b)) \ {b}
```



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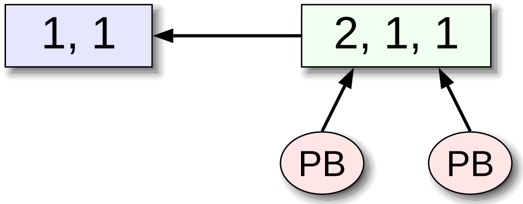

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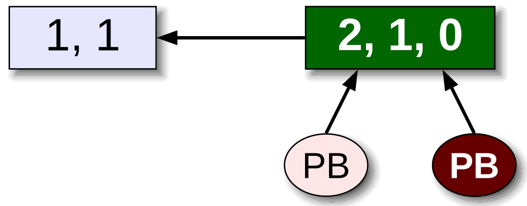

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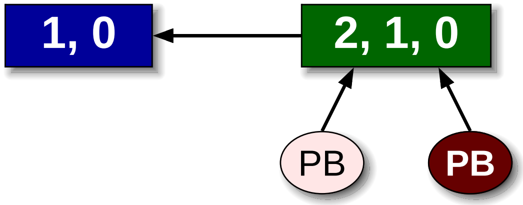

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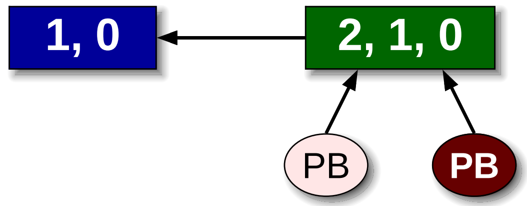

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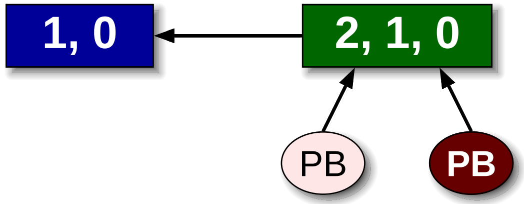

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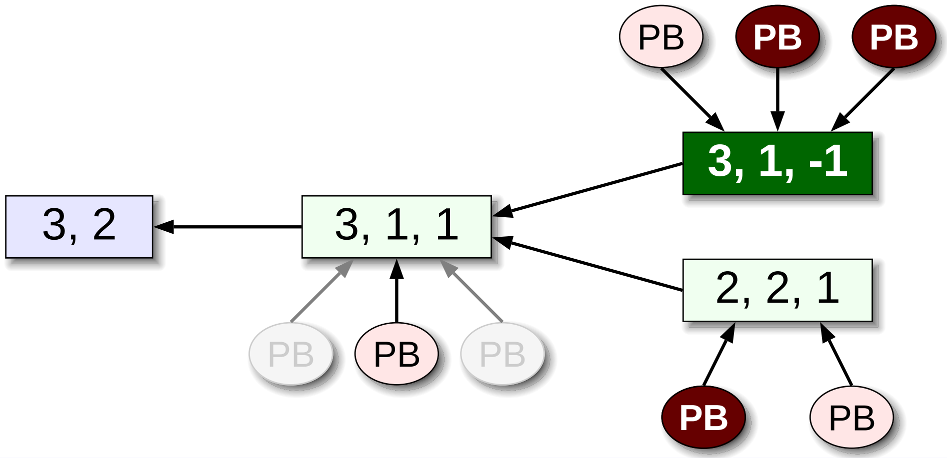

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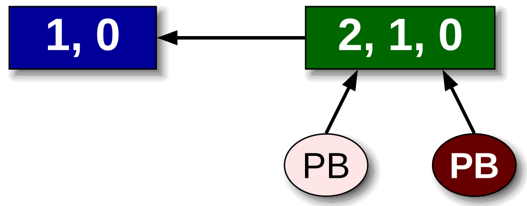

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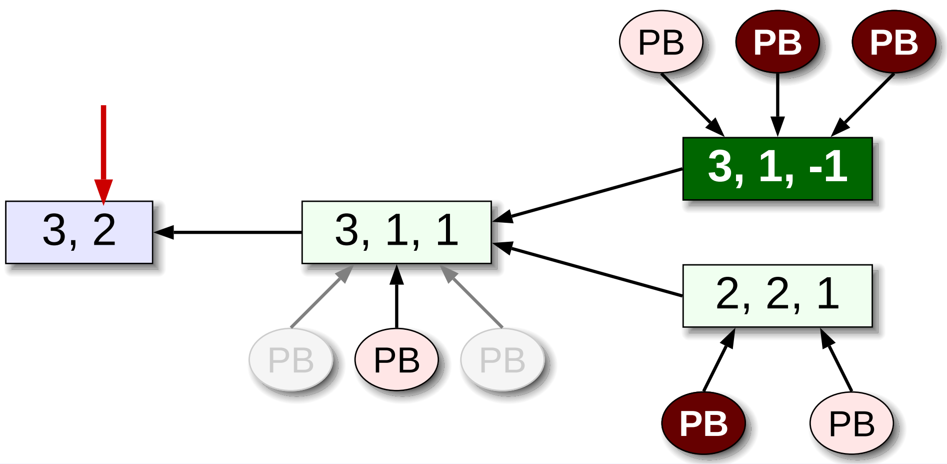

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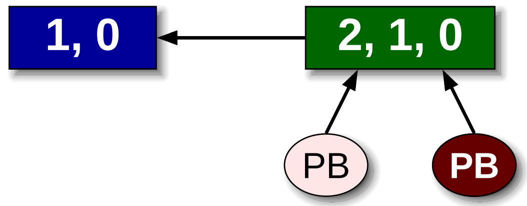

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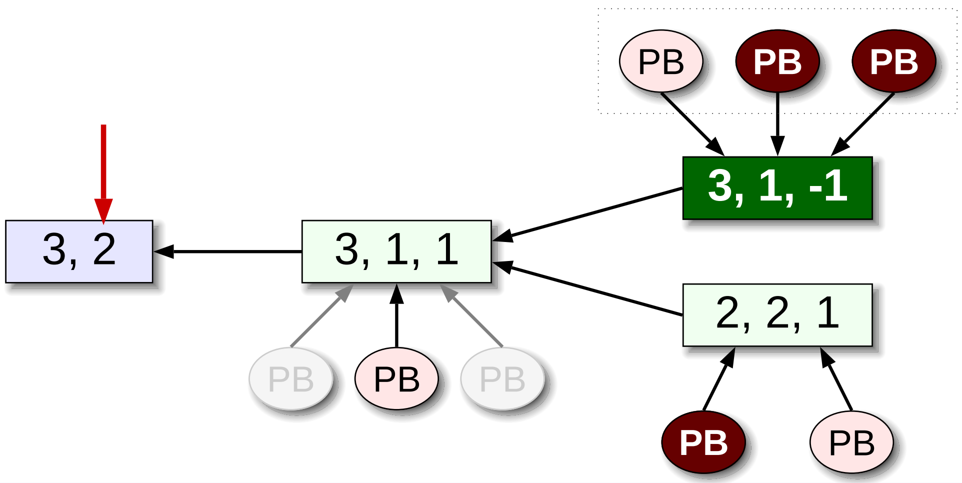

- Two sets left to synchronise
- When complete, only one of the interleaving processes will be resumed (queue implementation provides fairness); set remains ready

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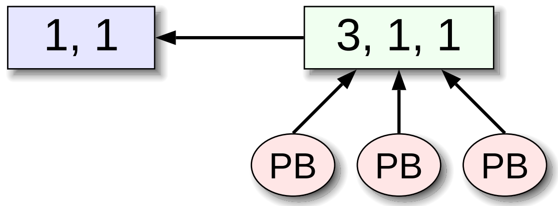

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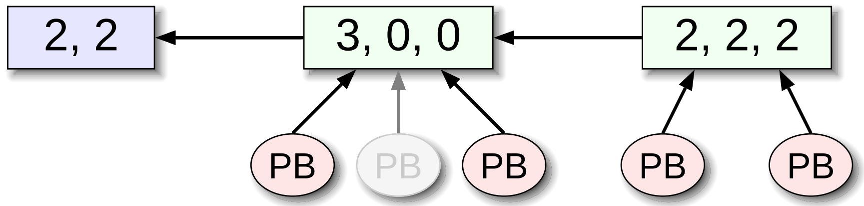

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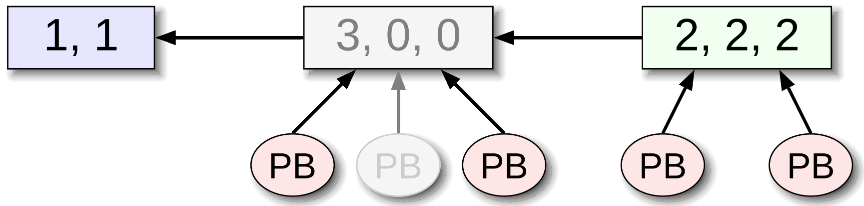

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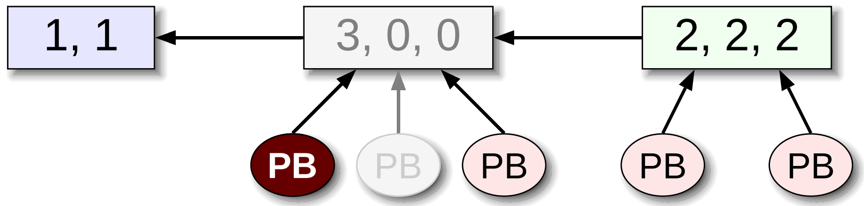

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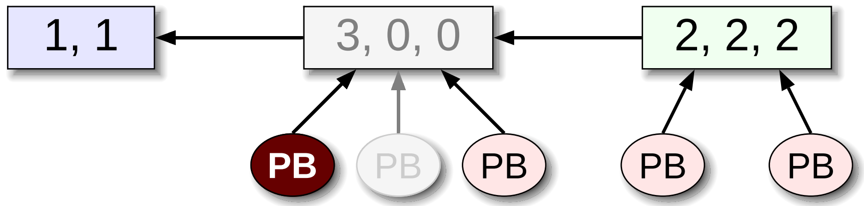

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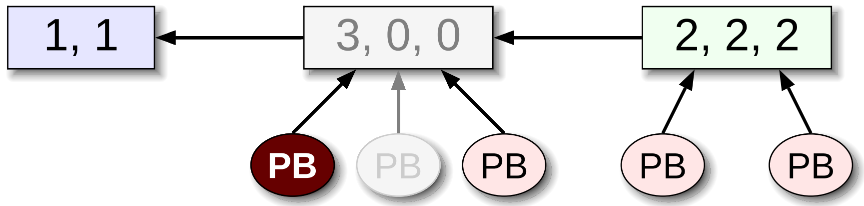

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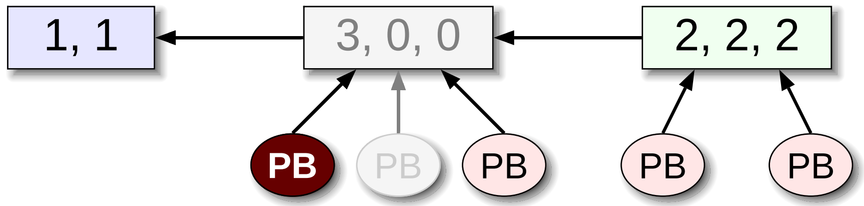

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- Also the top-level sync may never occur because down-count is already at zero
- An early thought at a solution was to introduce a **missing-count**, separate to sync-count, but this breaks down in **M-of-N** interleaving

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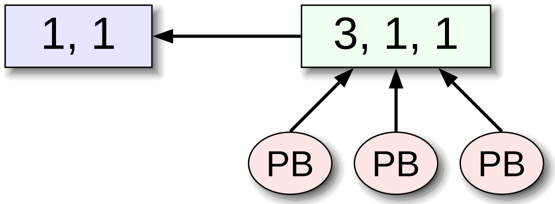
- One functional solution is to use nested barriers, as is almost supported:



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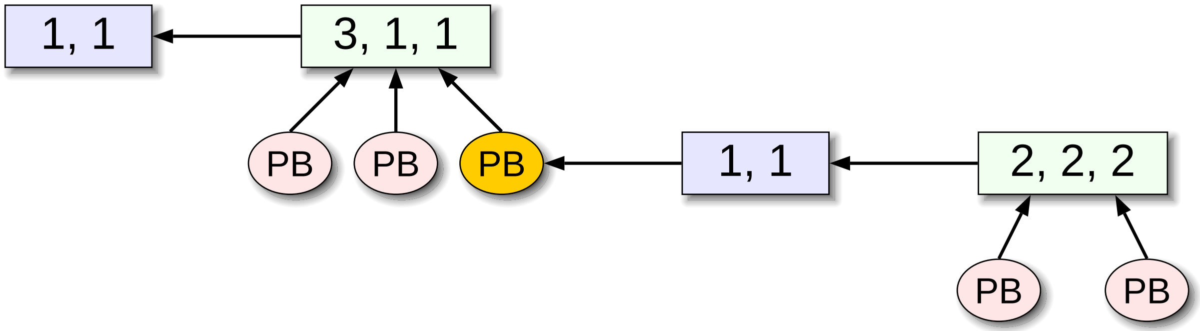

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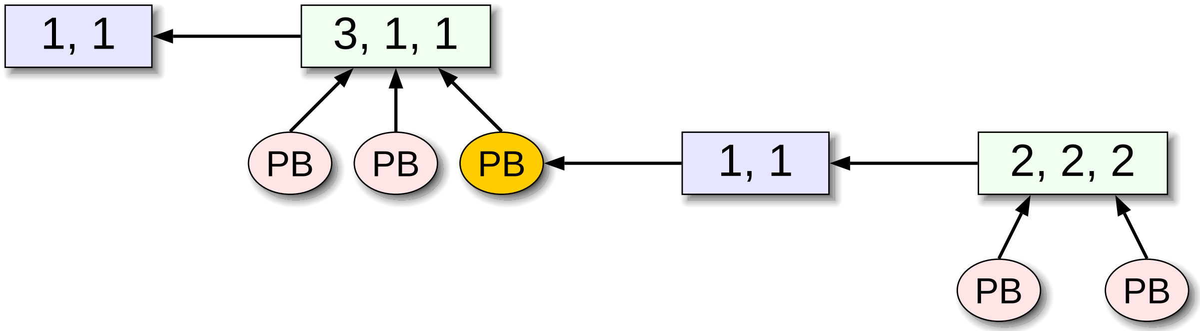

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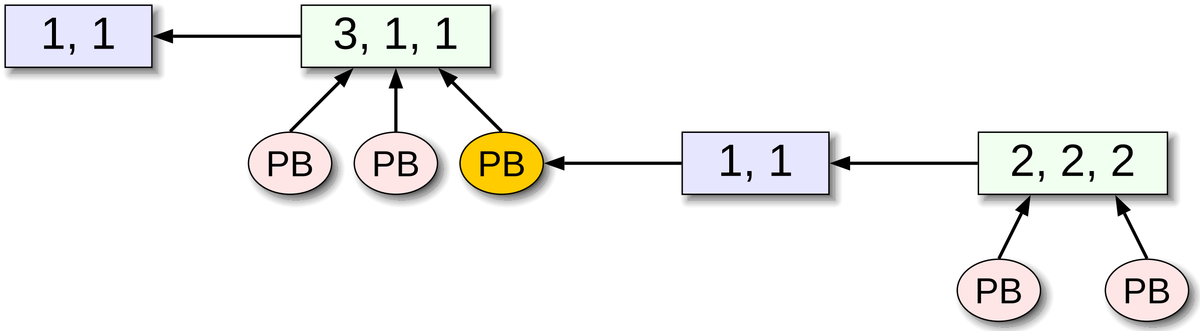

- Problem with this solution is the run-time overhead — **proc-barrier** operations will need to test for sub-barriers and handle accordingly
- There may be a better solution, but haven't found it yet..

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  santa (e.sync, r.sync)
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- Some outstanding issues relating to the **sync-count** when processes resign **in-par** — e.g. when there are only 2 elves left, are they allowed to meet with santa ?

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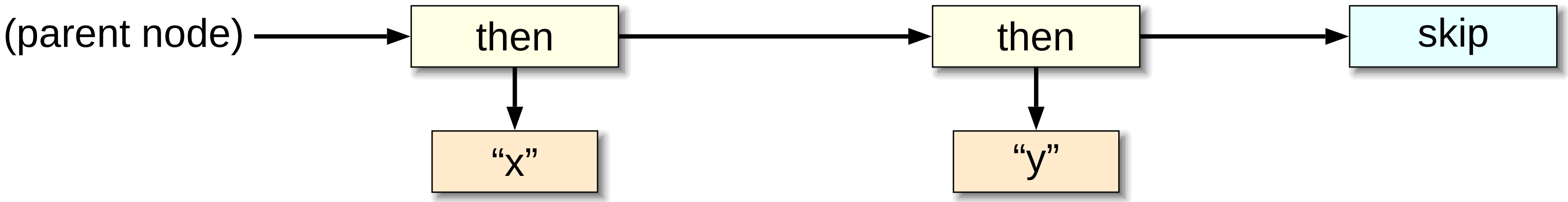

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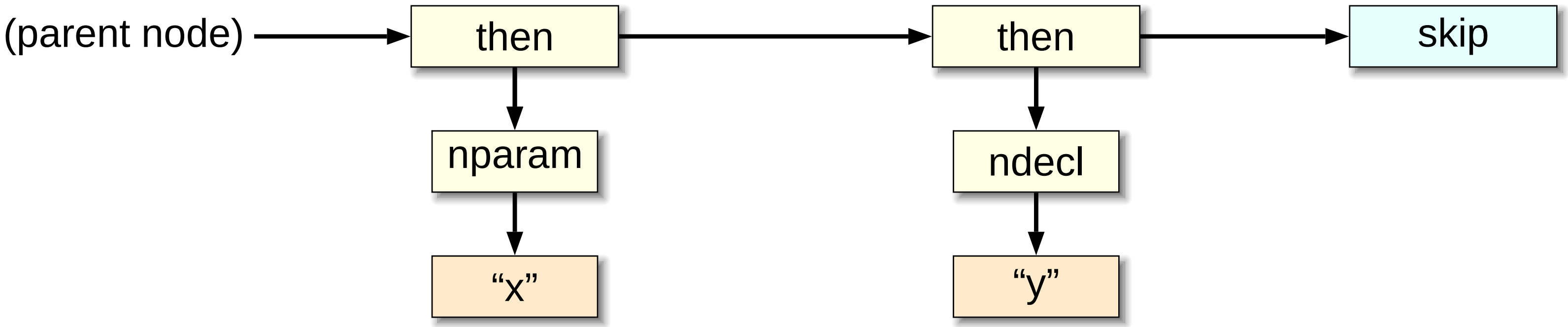

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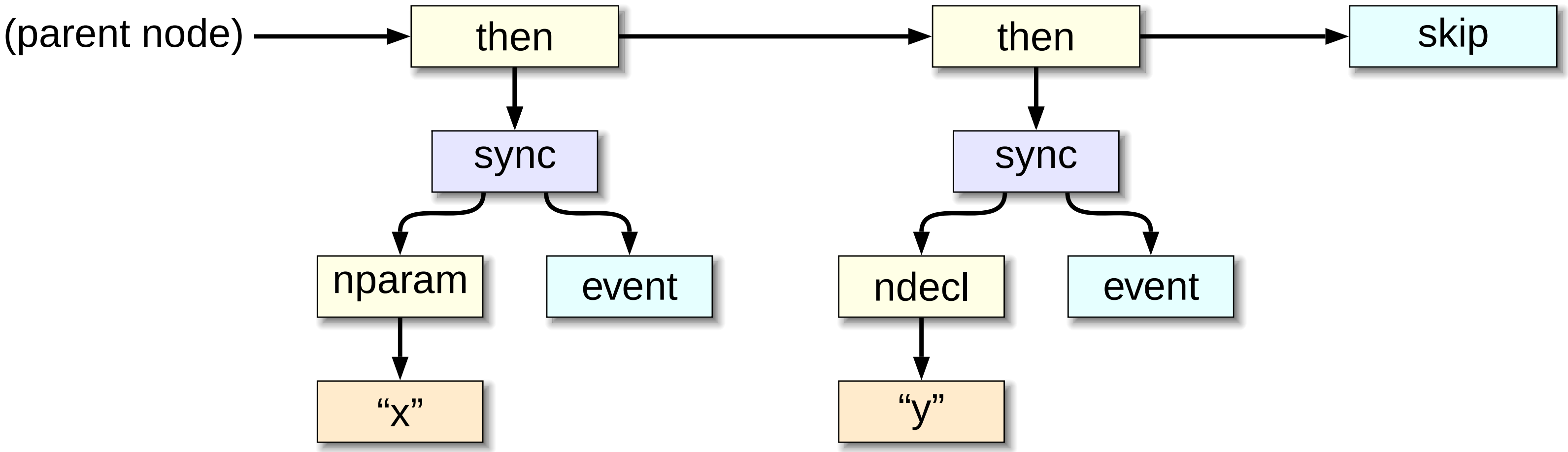

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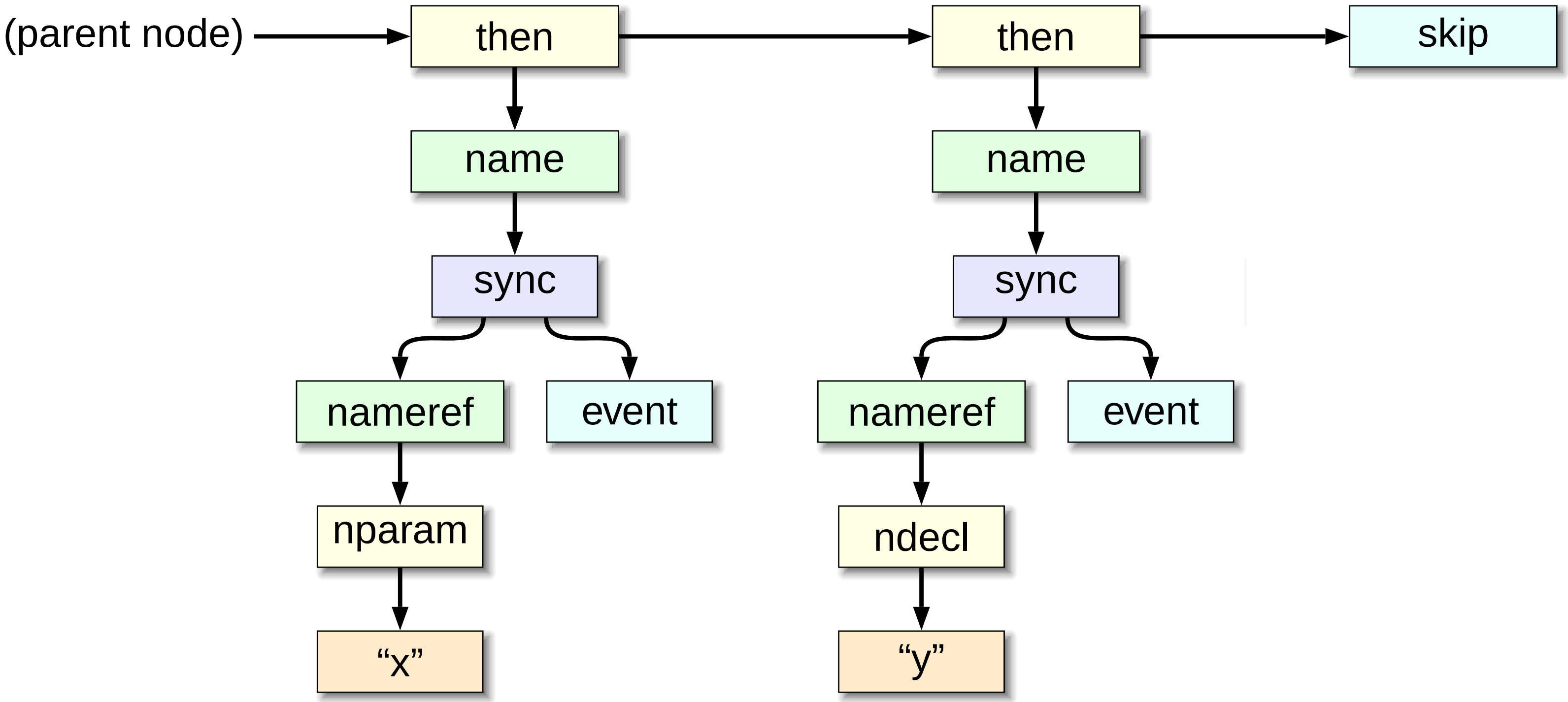

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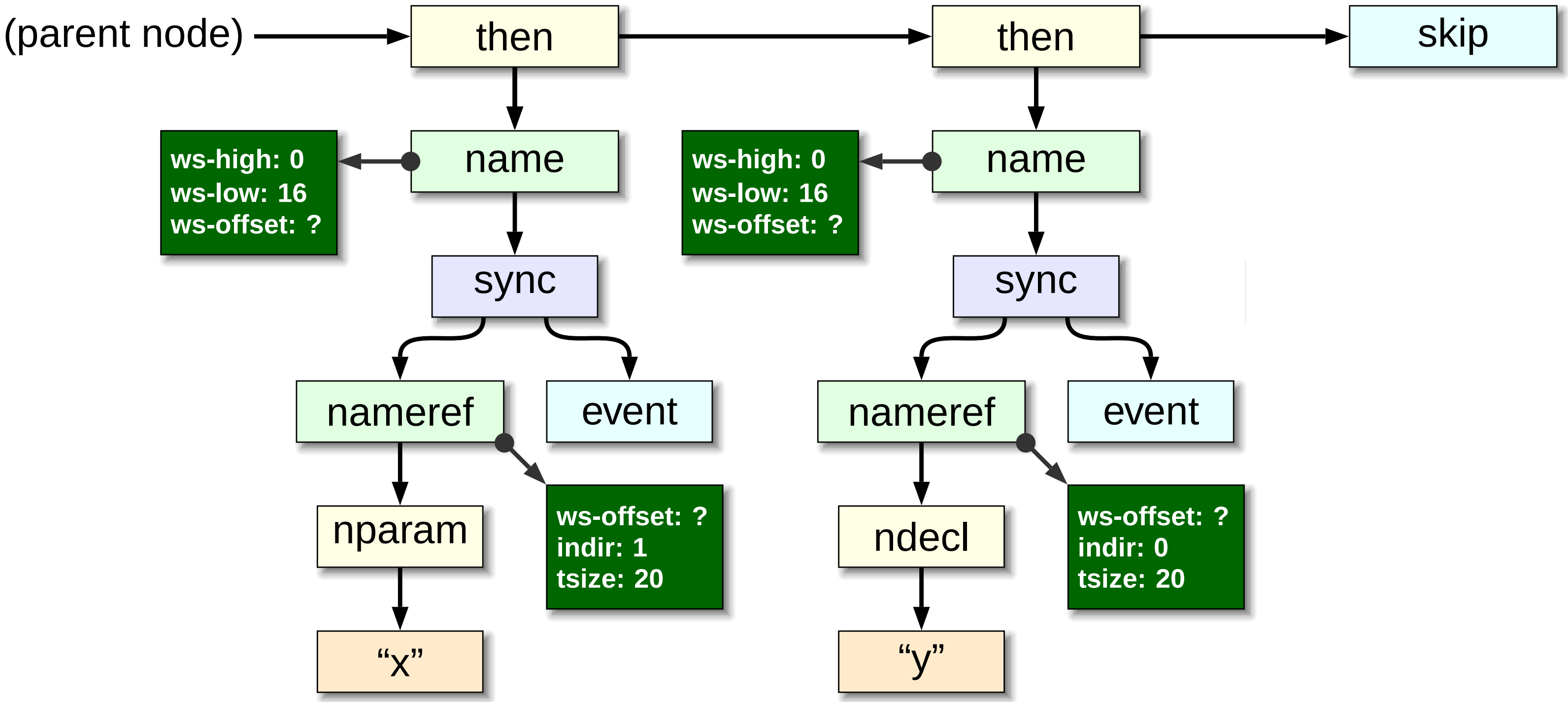

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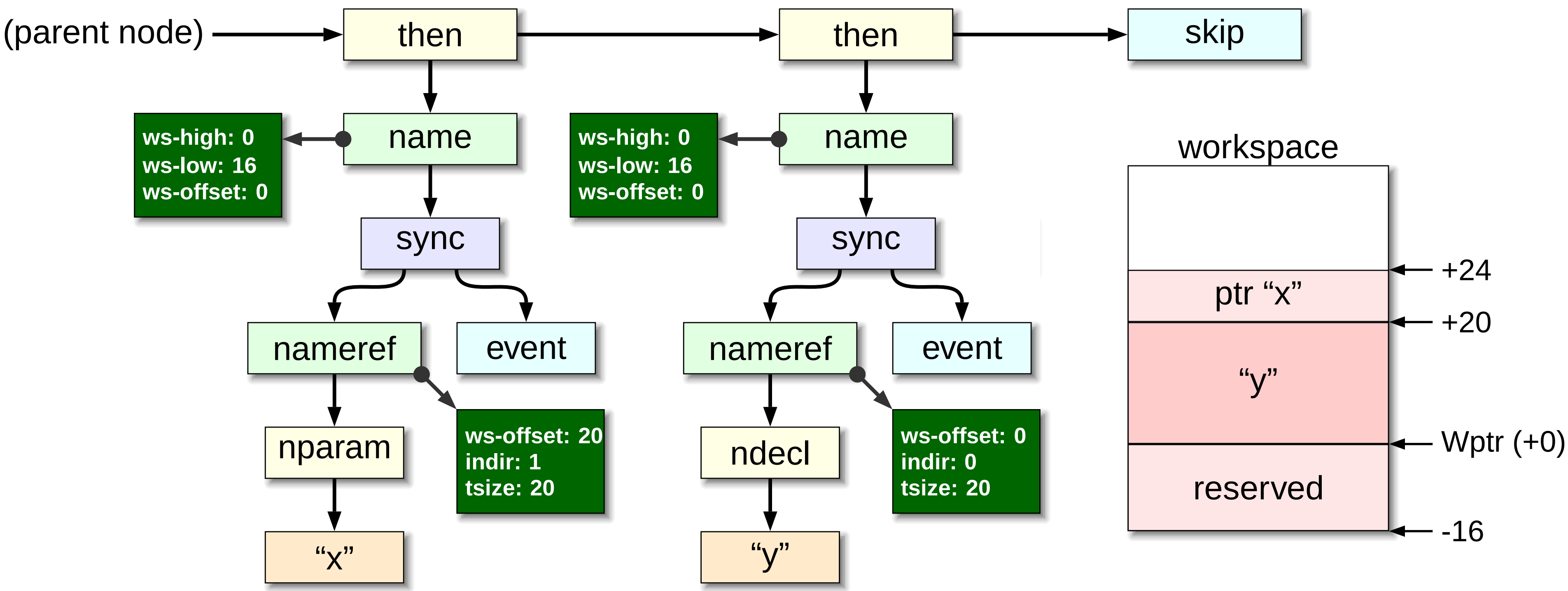

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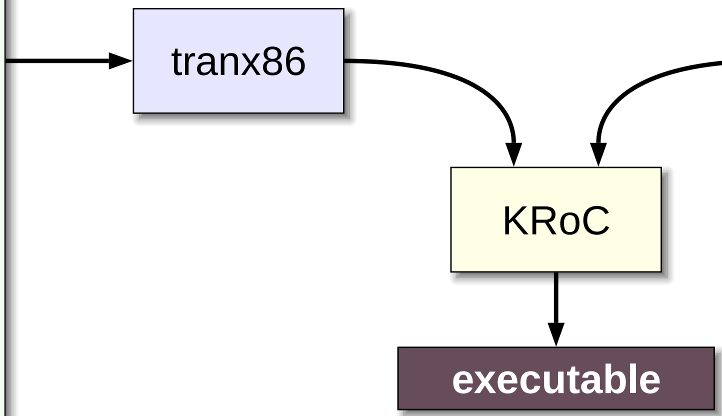

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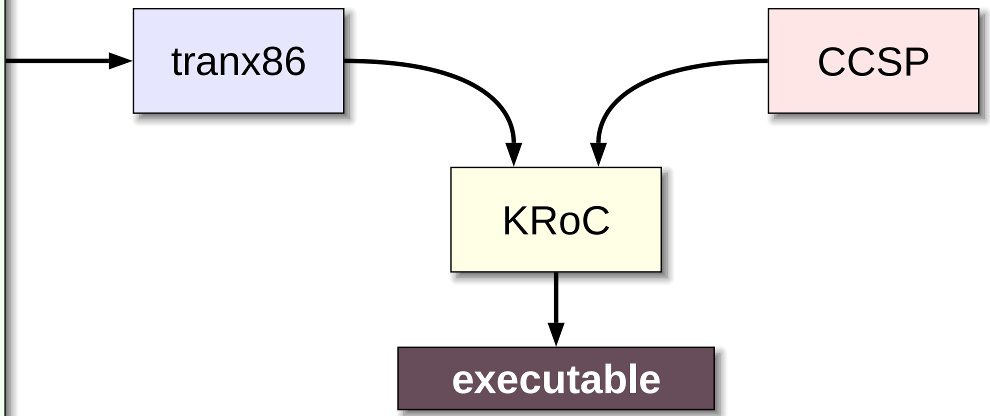

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<?xml version="1.0" encoding="iso-8859-1"?>
<nocc:libinfo version="0.1.4">
  <library name="commstime" namespace="">
    <libunit name="commstime.occ">
      <signedhash hashalgo="sha256" value="28373a..." />
      <proc name="CONSUME" language="mcsp"
          target="etc-kroc-unknown">
        <descriptor value="CONSUME(in,report)" />
        <blockinfo allocws="44" adjust="12" />
      </proc>
      ...  other processes
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CONSUME (in,report)    ::= @x.((;[i=1,1000000] in); report -> x)

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- Because there are currently no timer facilities, have to rely on the time between ‘report’ outputs (every million cycles)
  - on a 2.4 GHz P4, time for a complete synchronisation with 2 process is approximately 250 nanoseconds (syncs implemented as single-guard `ALT`s) (using Welch’s algorithm with dynamic wait-queue allocation)

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- Items for future consideration:
  - different **environments** — e.g. for graphical visualisations
  - adjustment of the syntax for FDR compatibility