

# Compiling CSP

or having fun with a new *occam- $\pi$*  compiler and CSP  
(and fringe presentation)



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- Motivation
- The new occam- $\pi$  compiler (fringe presentation)
- Compiling CSP
- Interleaving multiway synchronisations
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# Motivation

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- ▶ **CSP**, Hoare's Communicating Sequential Processes, is a process algebra for describing **concurrent** processes and their interactions
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- ▶ 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- $\pi$  compiler to replace the existing compiler in KRoC
  - the existing compiler is becoming increasingly 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
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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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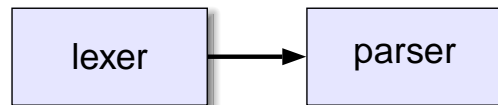
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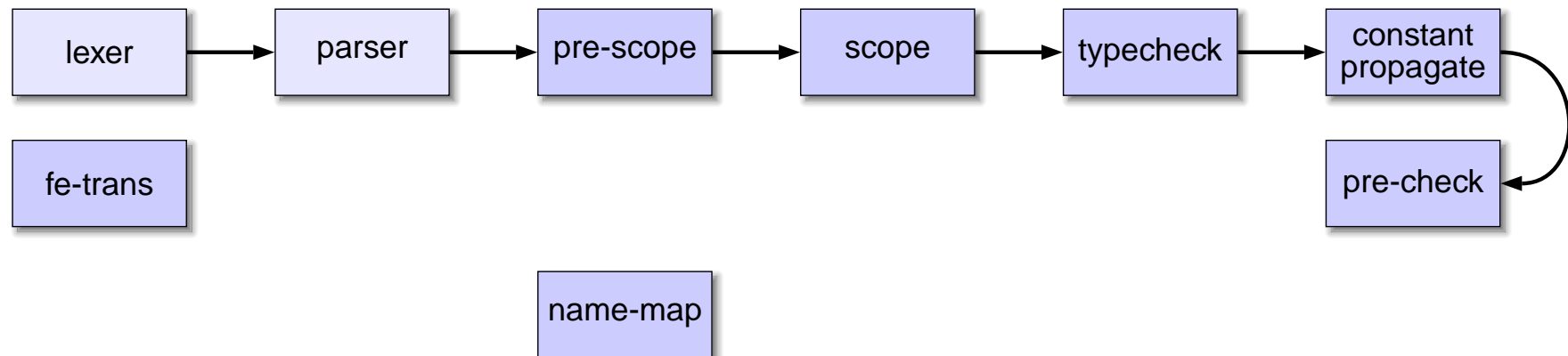
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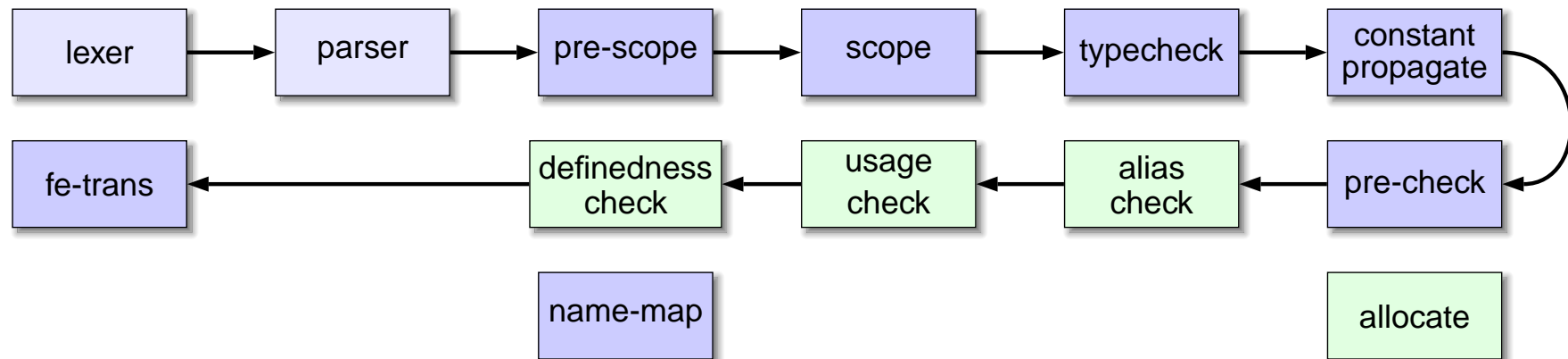
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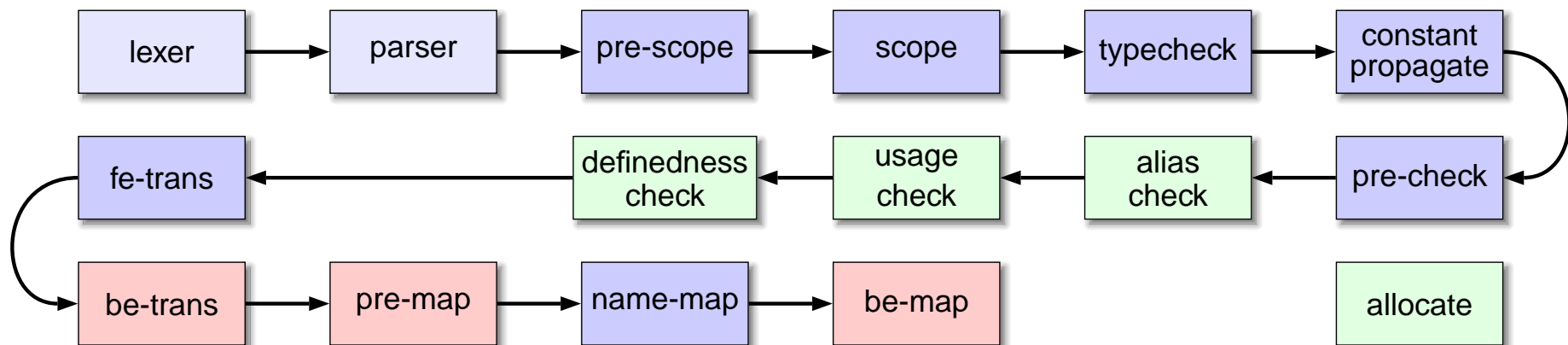
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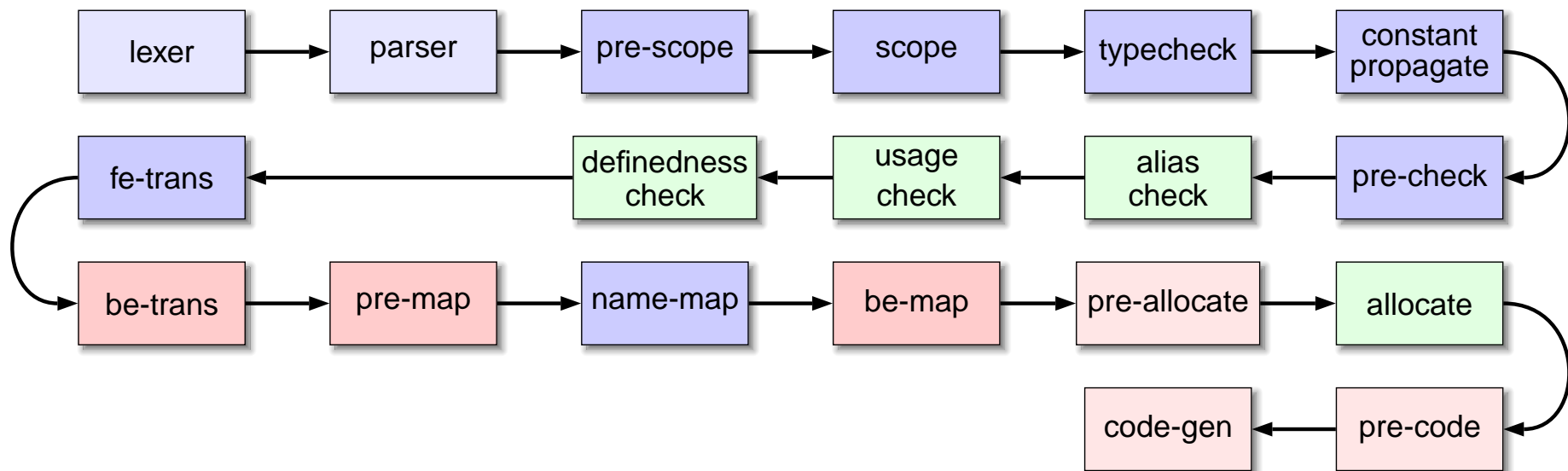
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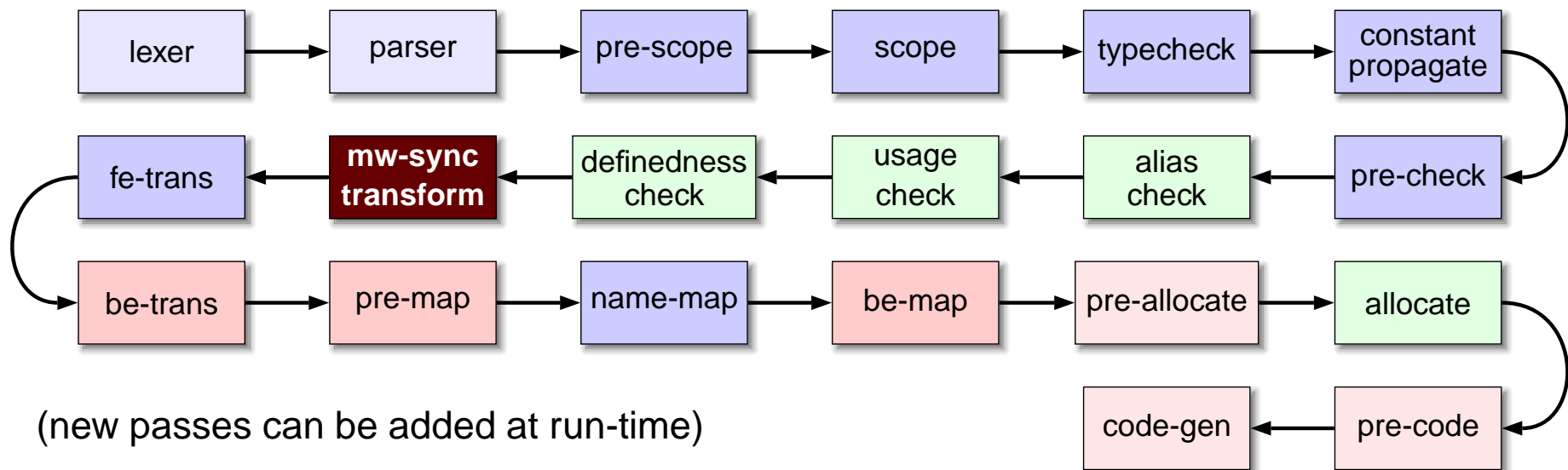
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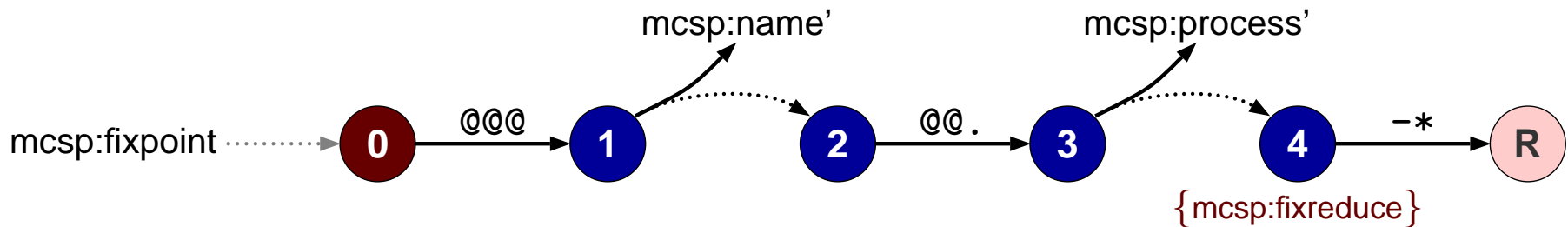
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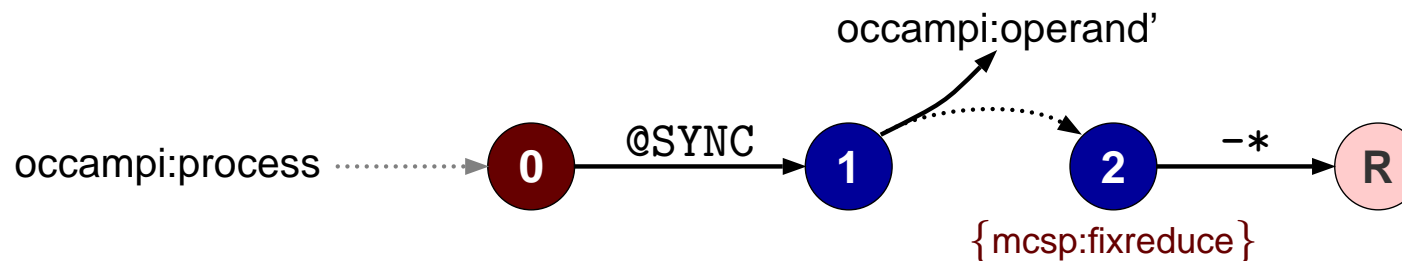
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- Compiler collects up DFA chunks, in **tables** and merges
  - later resolution of **sub-parses** (branches out of the DFA)

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nodetag  occampi:sync  "occampi:actionnode"
reduce  opi:syncreduce "SNON+00C[occampi:sync]3R-"
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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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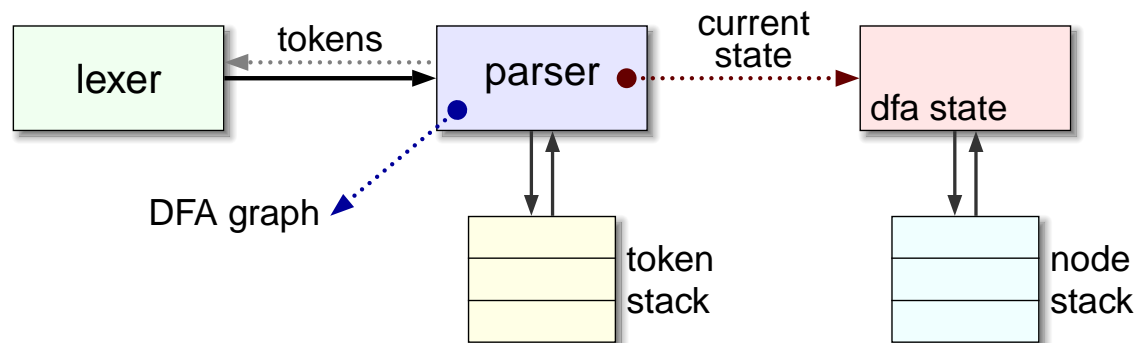
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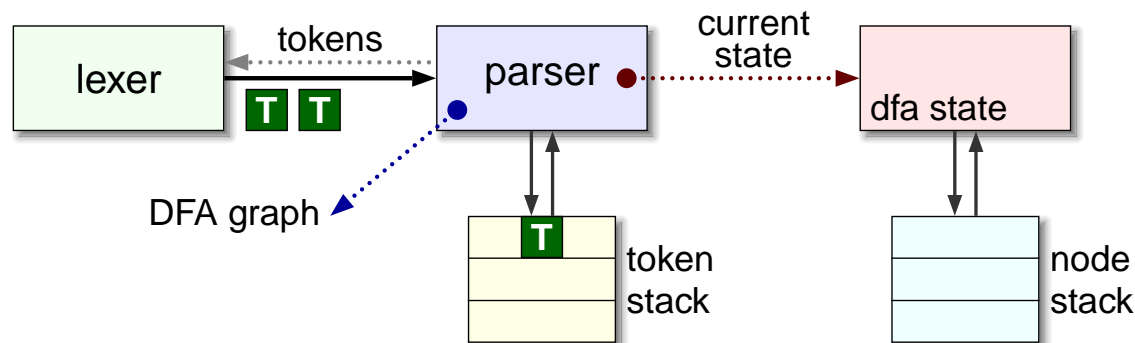
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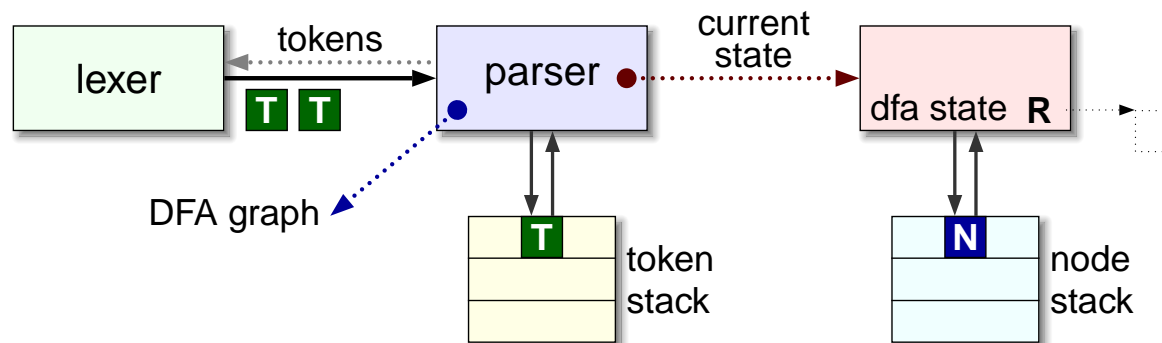
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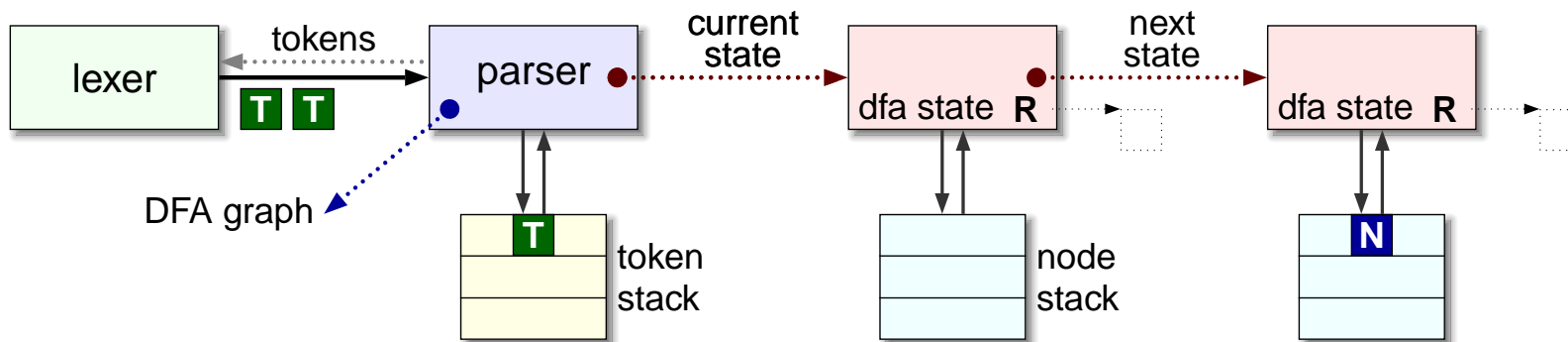
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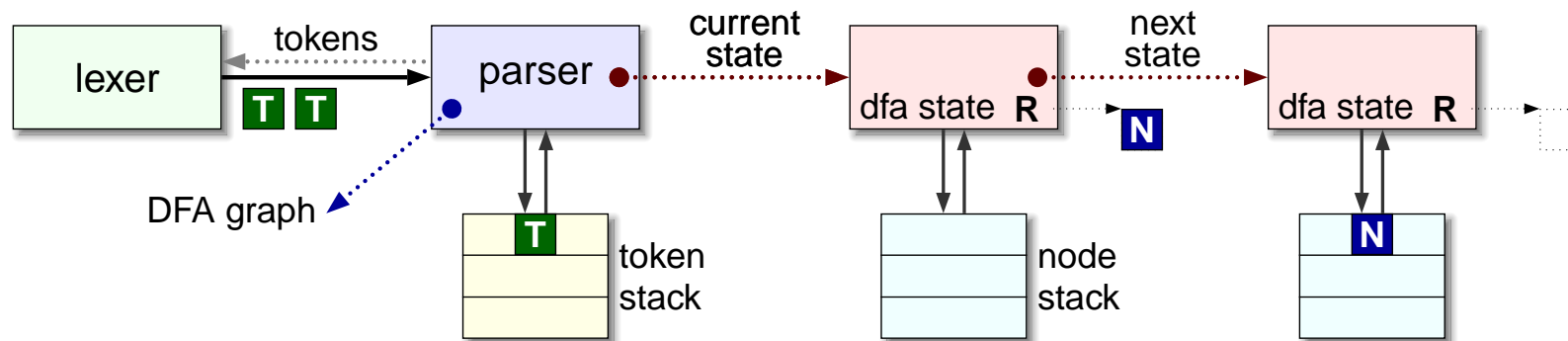
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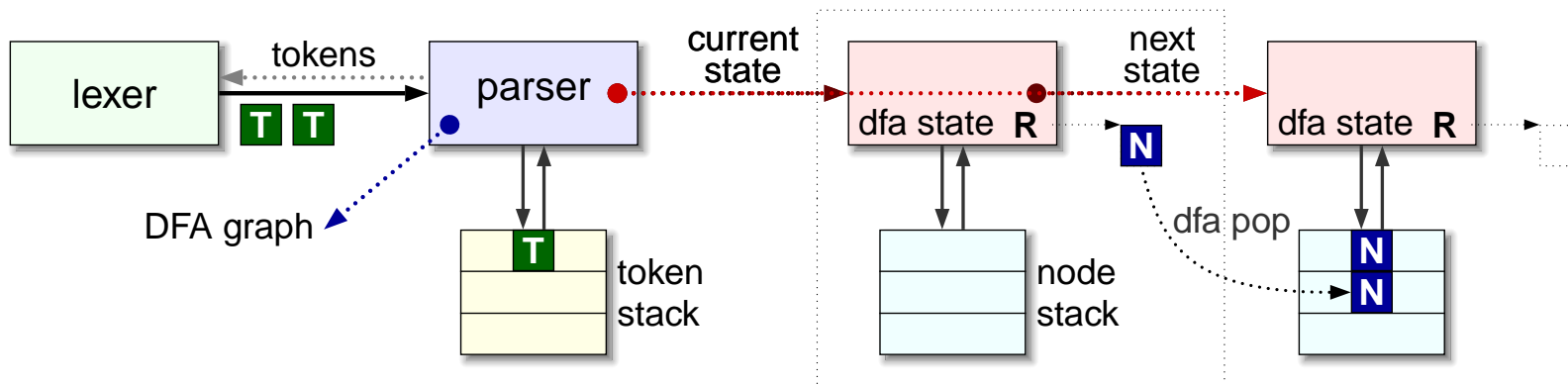
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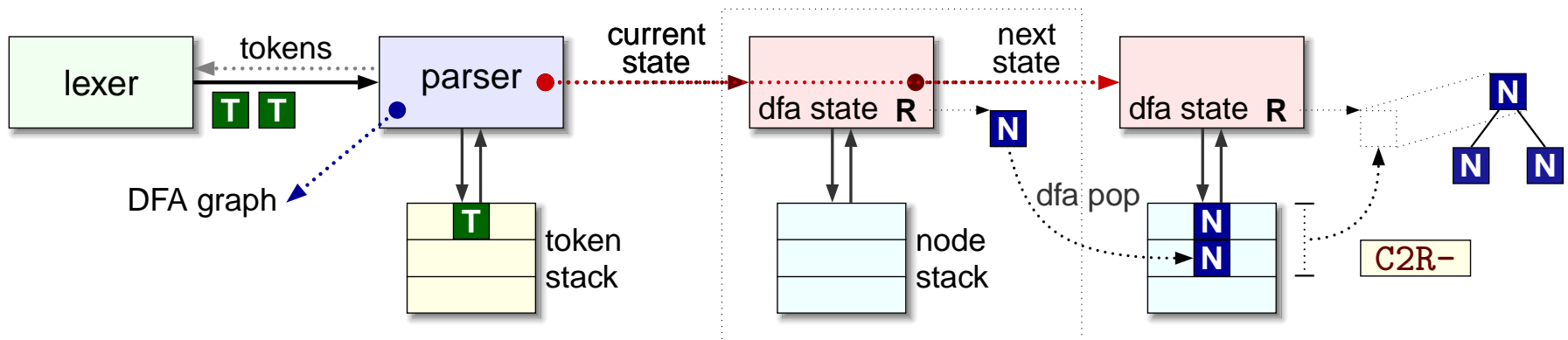
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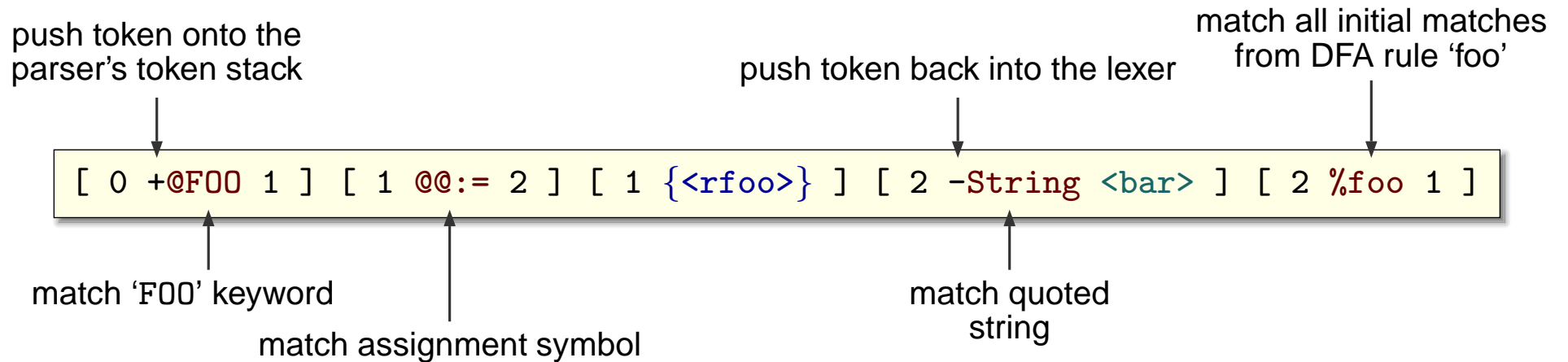
push token onto the  
parser's token stack

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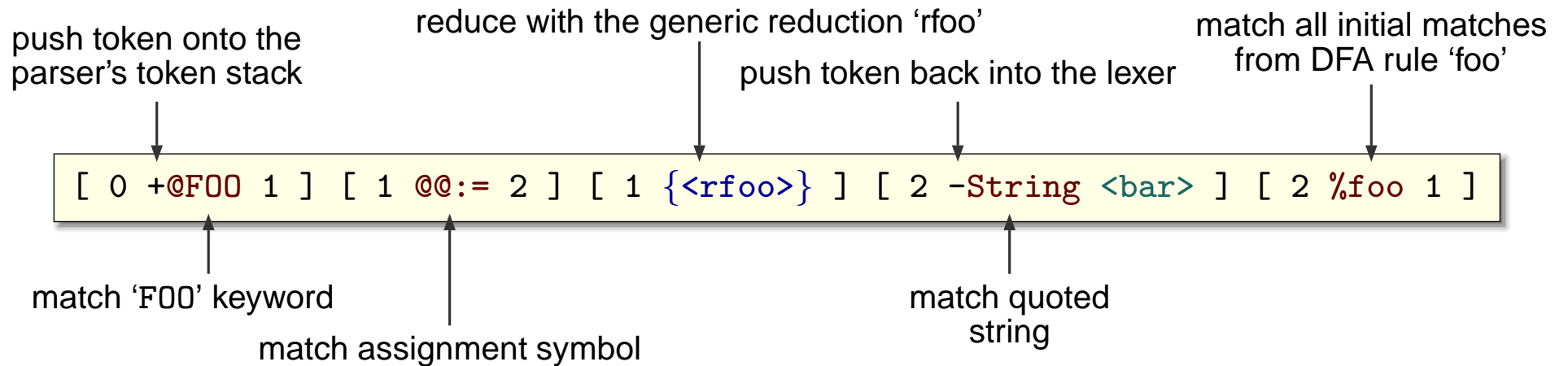
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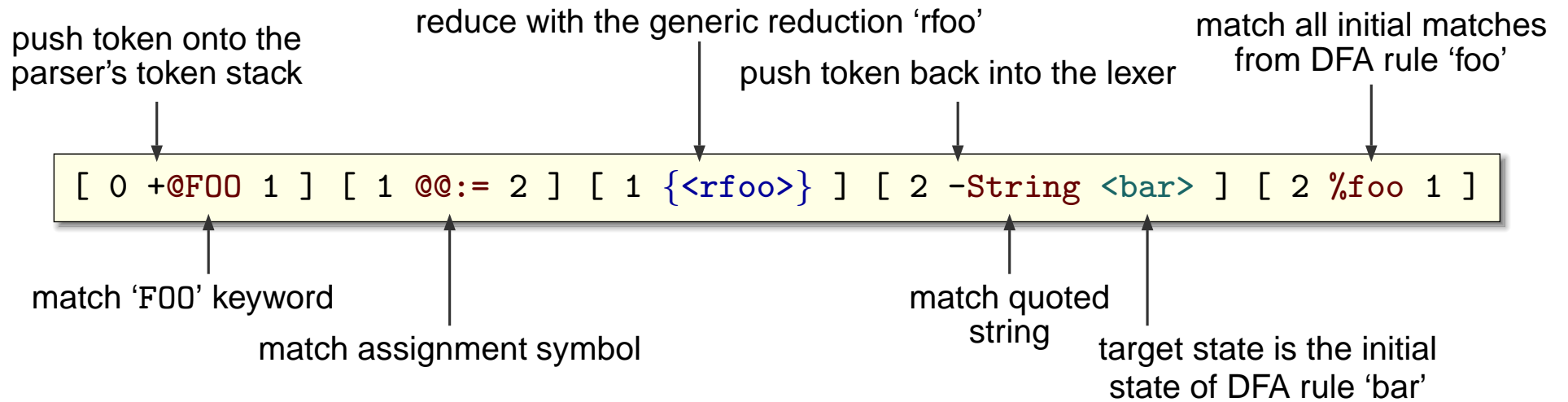
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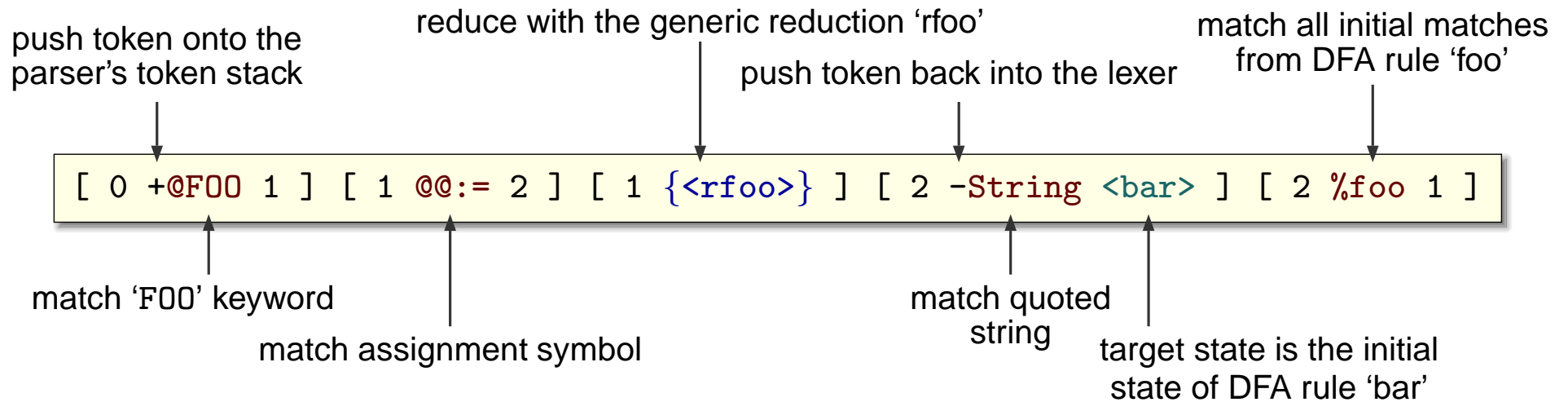
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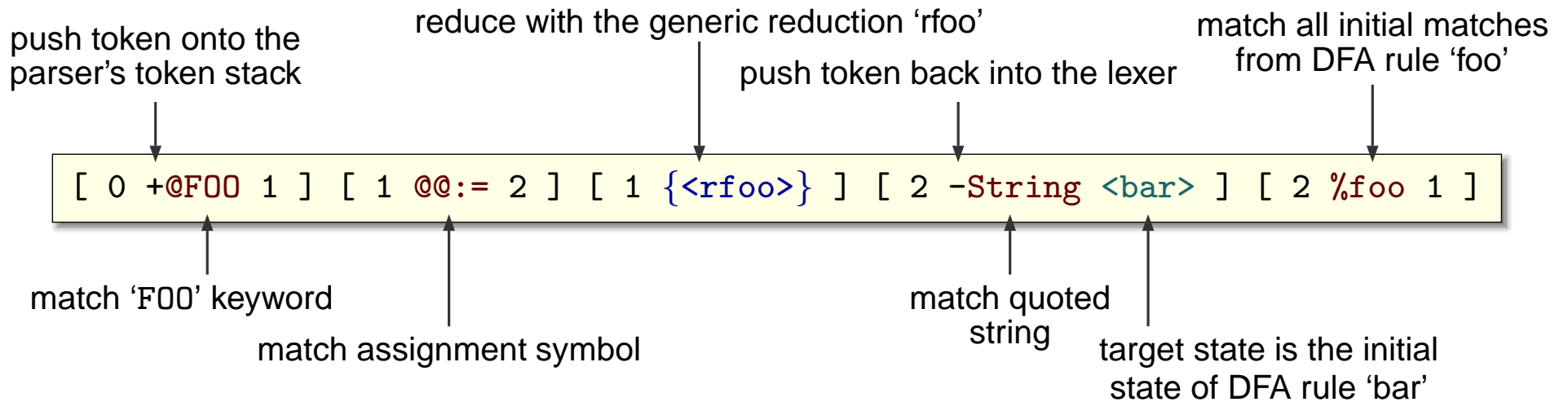
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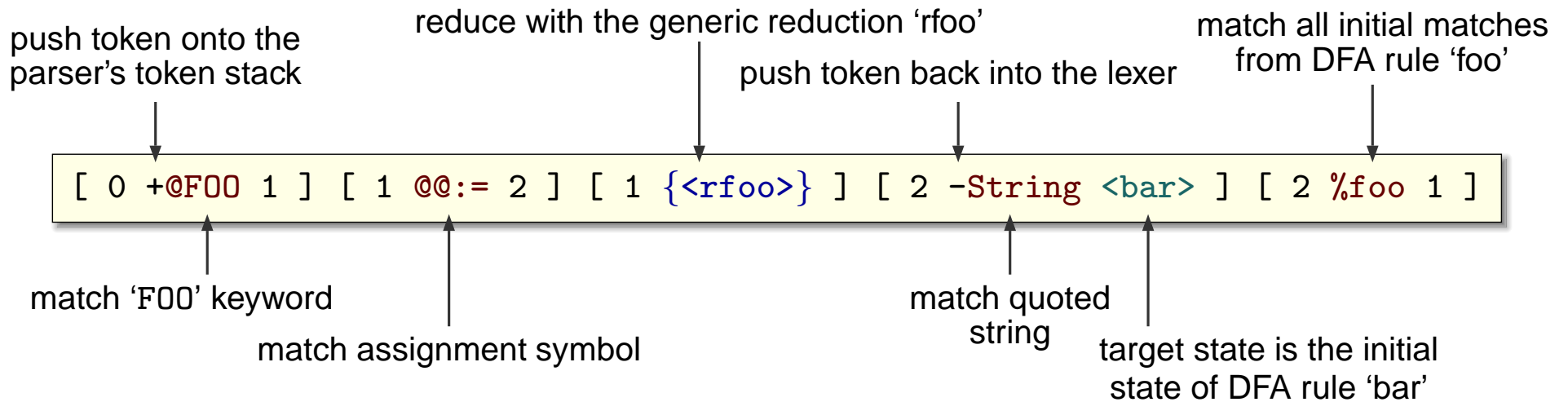
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- DFA edges (matched **transitions**) with no target pop the DFA state
- Parser for a null language: mylang ::= [ 0 \* 0 ] [ 0 End ]

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- Because the whole thing hangs together using structures containing function pointers, easy for code to intercept these and selectively override
  - not entirely unlike **aspect orientation**, albeit quite explicit
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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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	<b>CSP</b>	<b>MCSP</b>
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stop	<i>STOP</i>	STOP
chaos	<i>CHAOS</i>	CHAOS
divergence	div	DIV
event prefix	$e \rightarrow P$	$e \rightarrow P$
internal choice	$(x \rightarrow P) \sqcap (y \rightarrow Q)$	$(x \rightarrow P) \mid \sim \mid (y \rightarrow Q)$
external choice	$(x \rightarrow P) \square (y \rightarrow Q)$	$(x \rightarrow P) \square (y \rightarrow Q)$
sequence	$P \circledast Q$	$P; Q$
parallel	$P \parallel Q$	$P \parallel Q$
interleaving	$P \parallel\parallel Q$	$P \parallel\parallel Q$
hiding	$P \setminus \{a\}$	$P \setminus \{a\}$
fixpoint	$\mu X.P$	$@X.P$

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# Interleaving Multiway Synchronisations

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  - **1 of N**: the CSP model (strictly speaking  $|||$  is a binary operator,  $N = 2$ , but NOCC will flatten nested interleaving)
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instead we could have written:

```
MACHINE (coin) ::=
  @x.(coin ->
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- 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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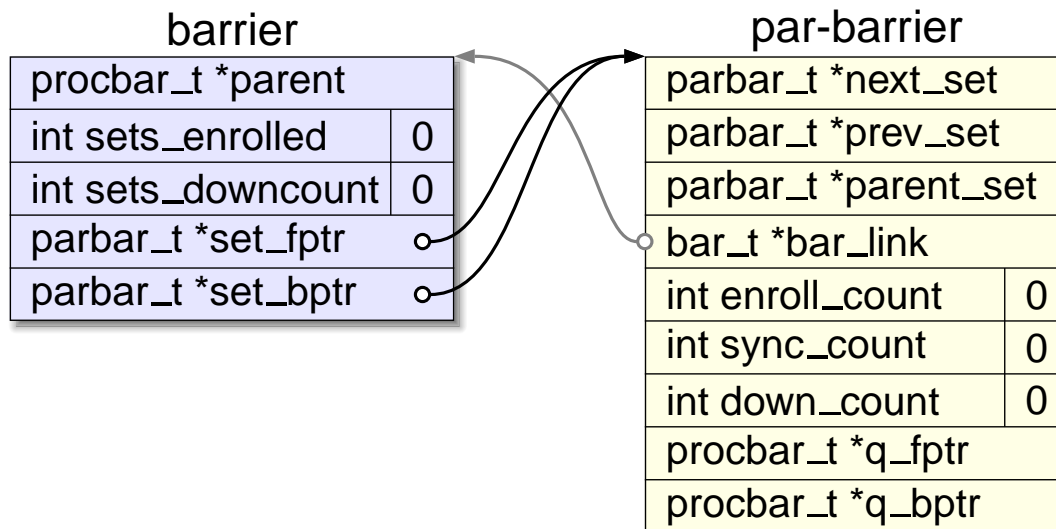
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barrier

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

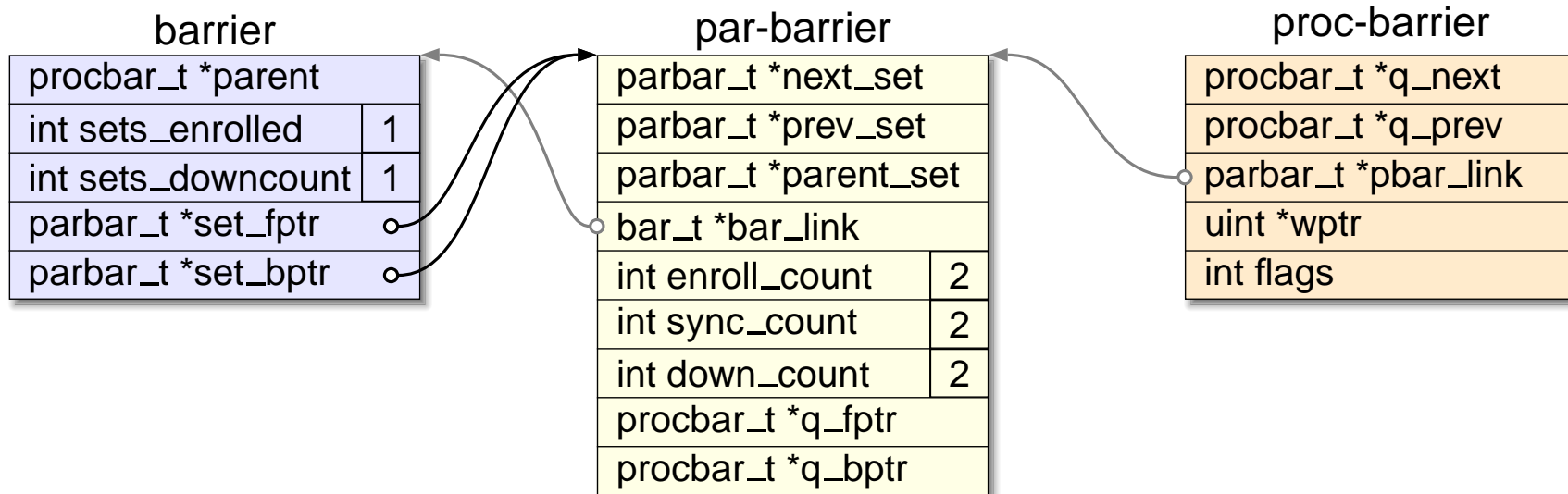
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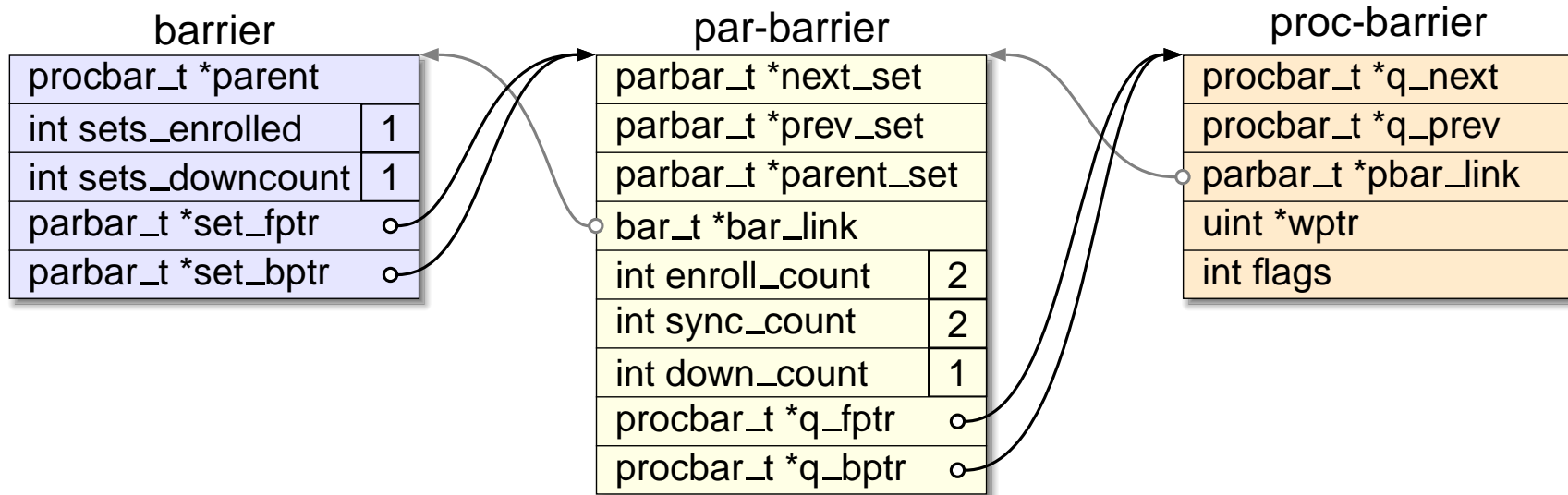
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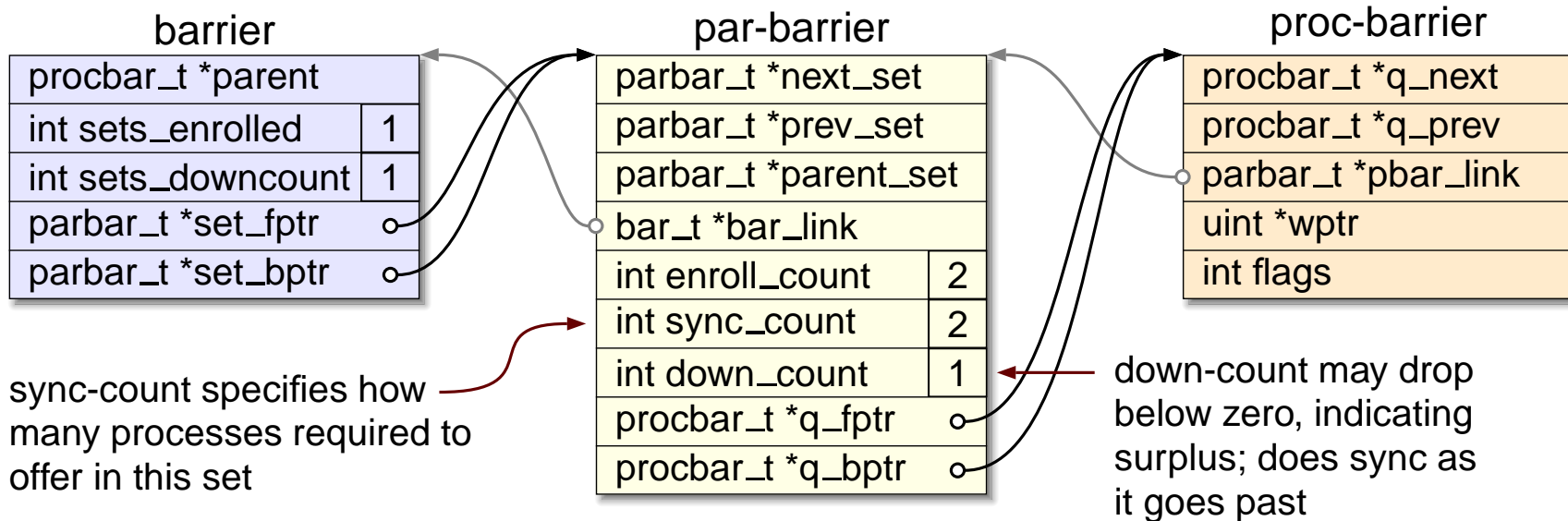
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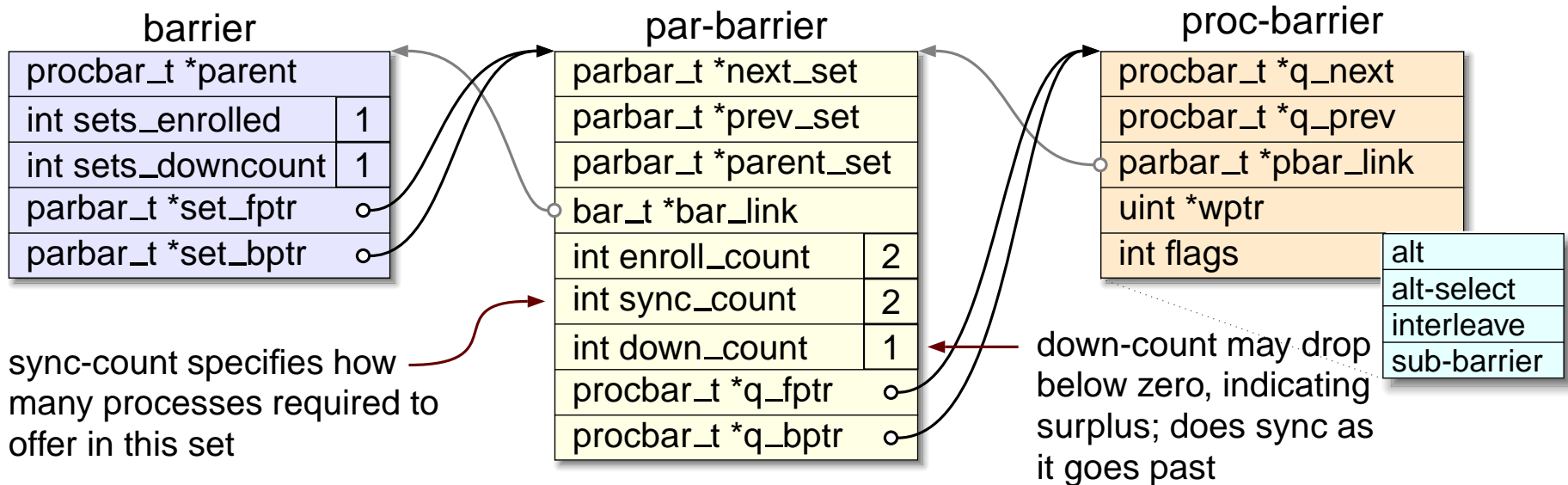
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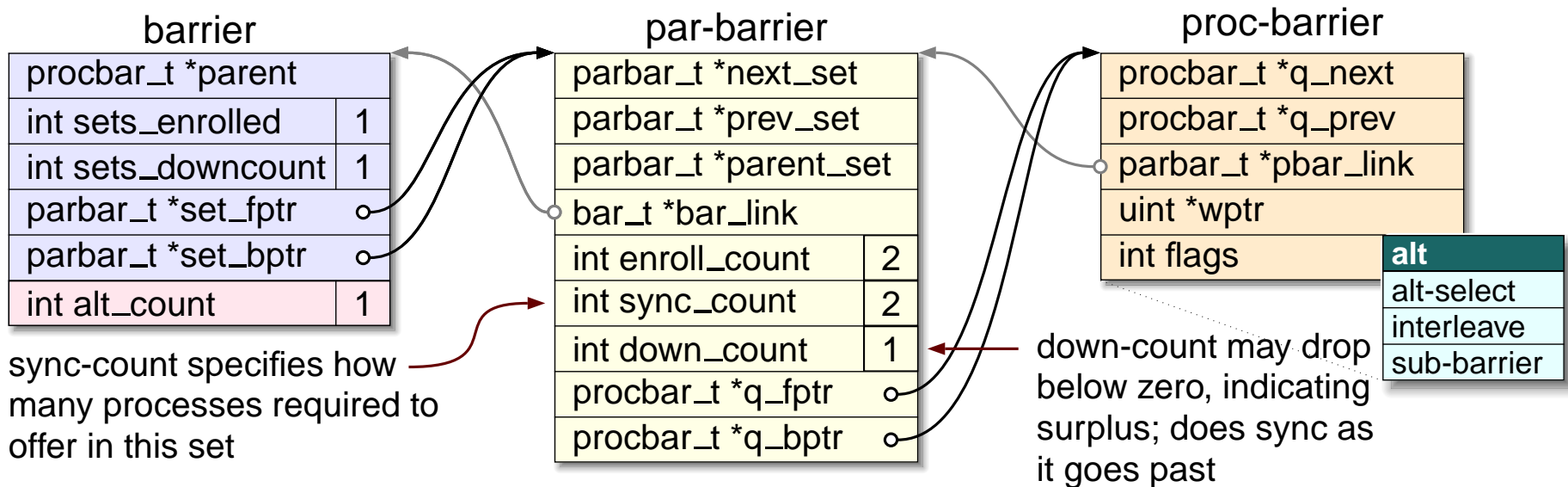
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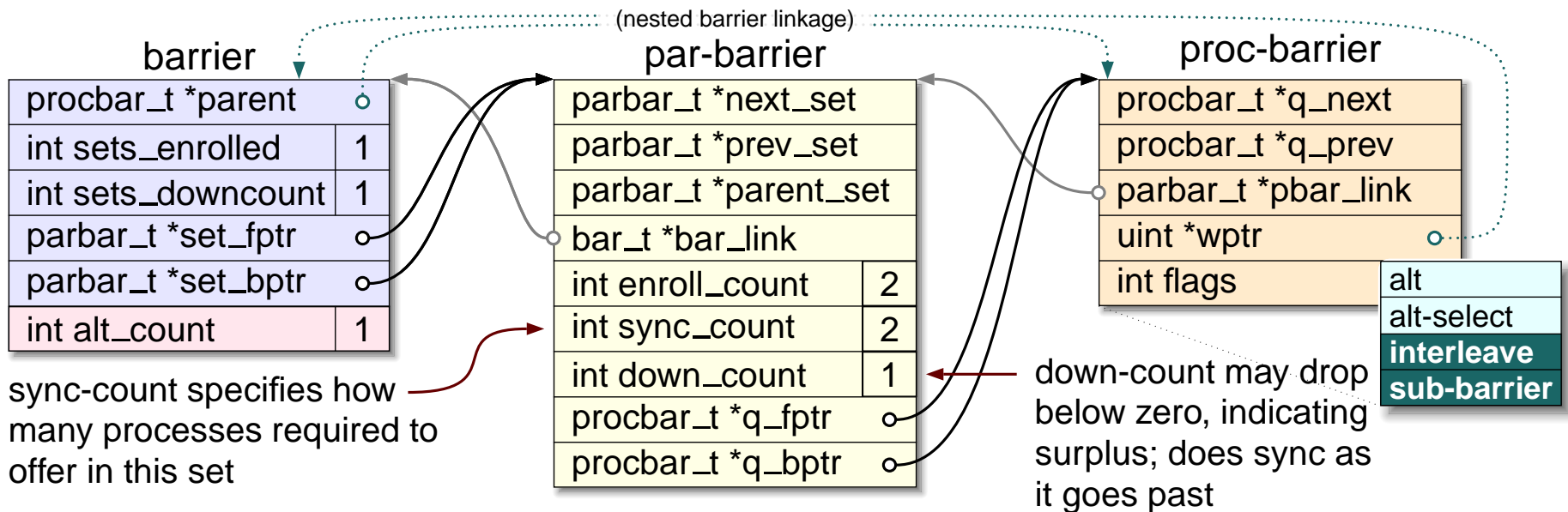
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- Certain cases of interleaving require nesting of these (or do they...)
  - only when interleaving processes go sub-parallel or sub-interleave

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```

```
PAR
```

```
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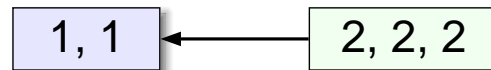
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```
0, 0
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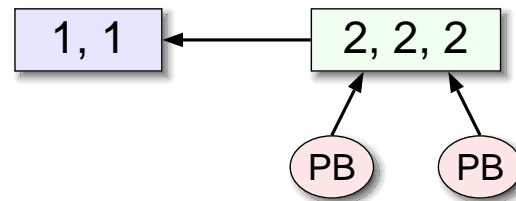
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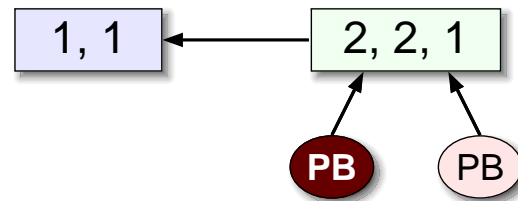
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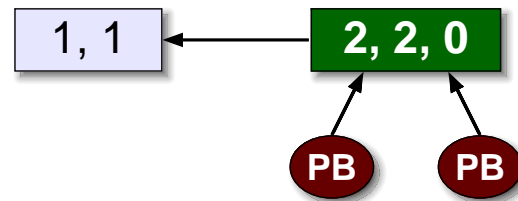


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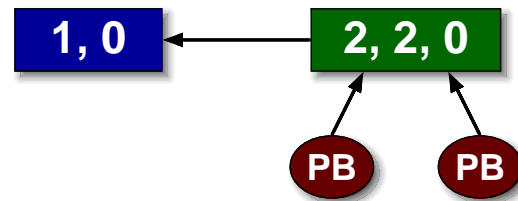


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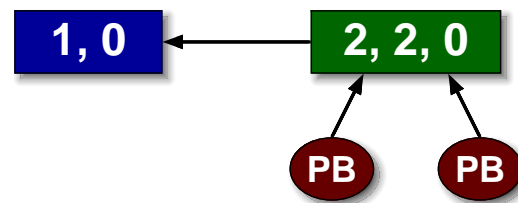
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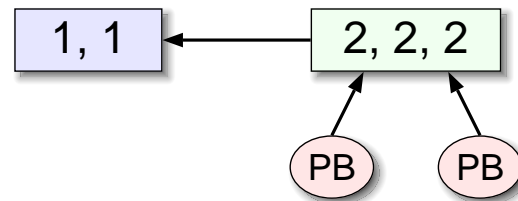
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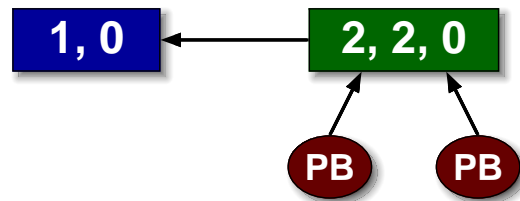


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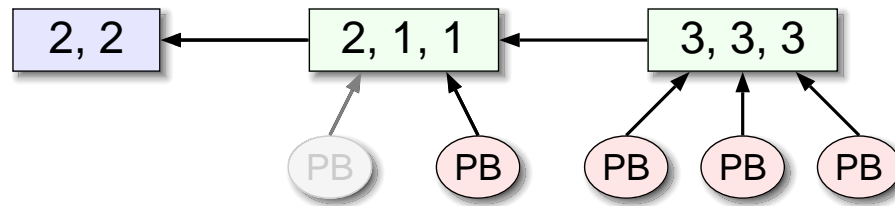
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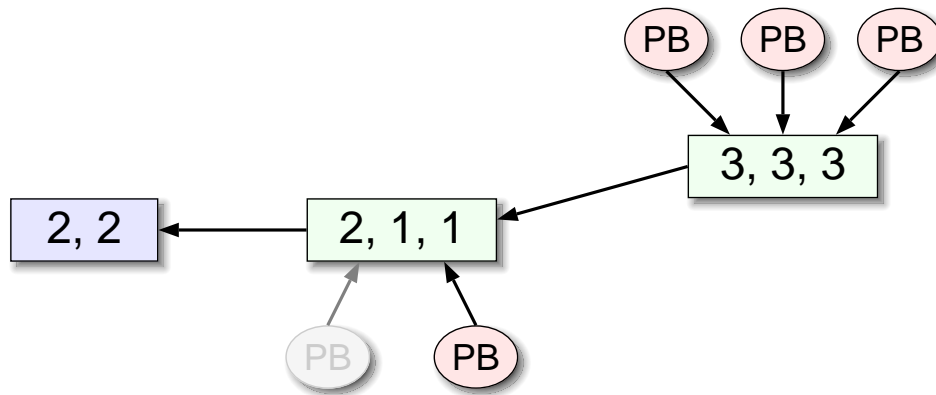


- Sub-parallelism (or interleaving) creates a logically upside-down tree; if P goes parallel with 3 sub-processes, its own is resigned

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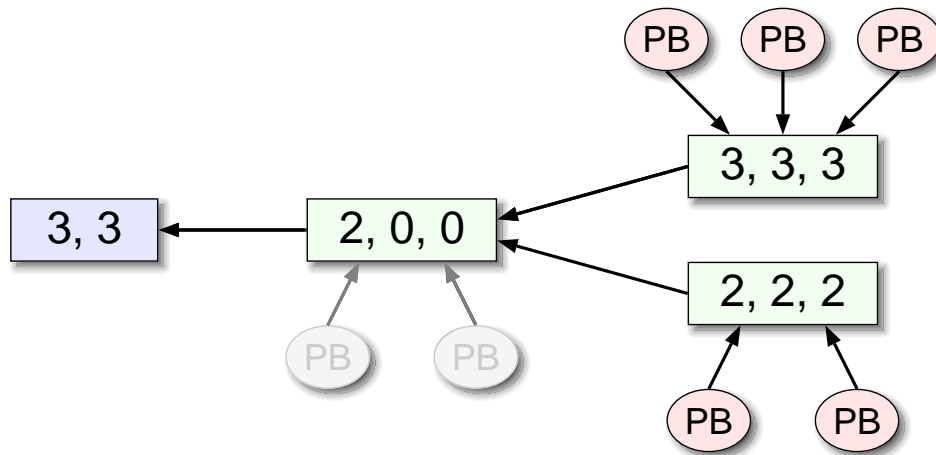
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► If the other branch (Q) goes parallel simultaneously:



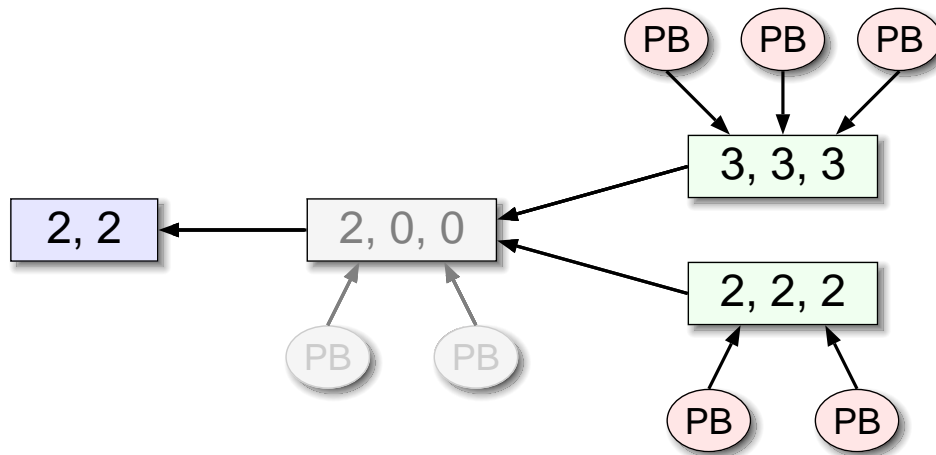
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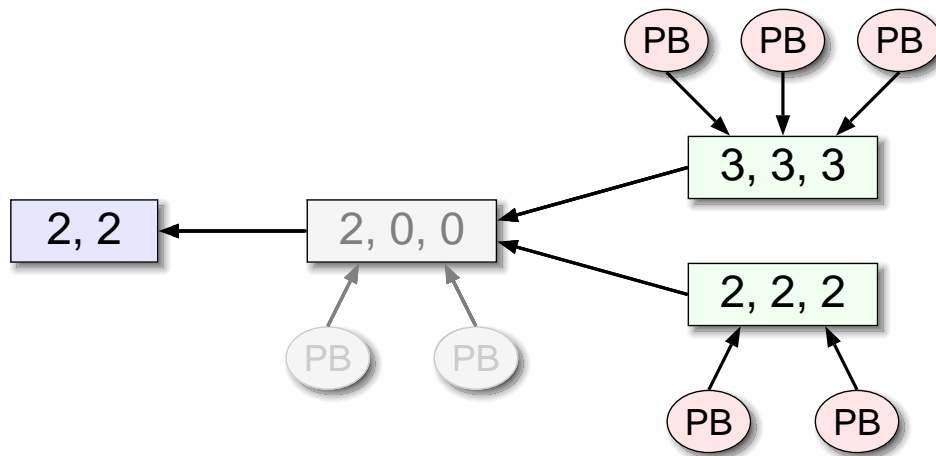
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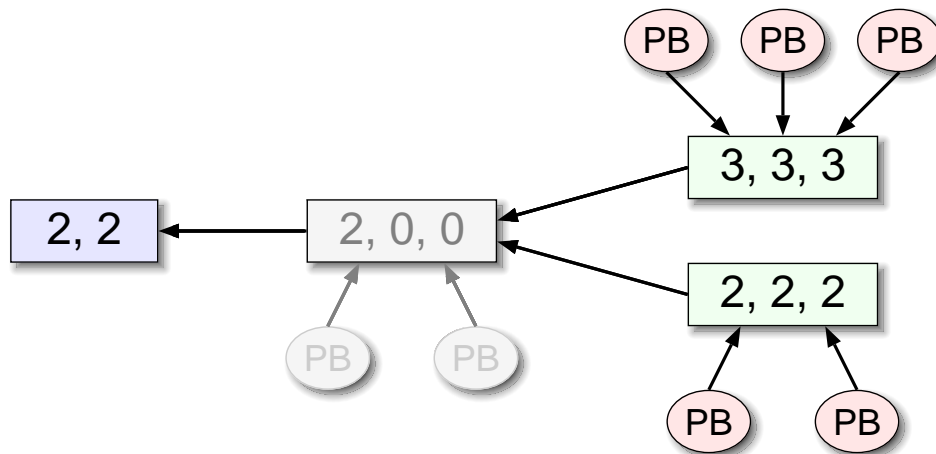
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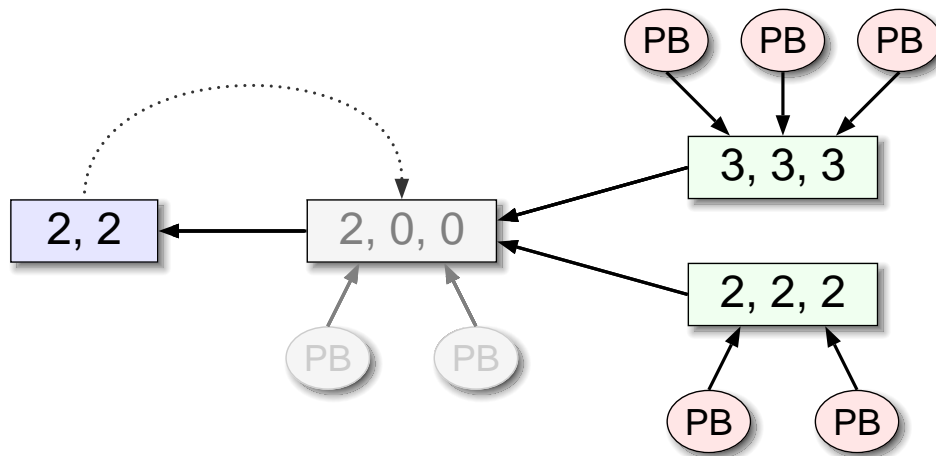
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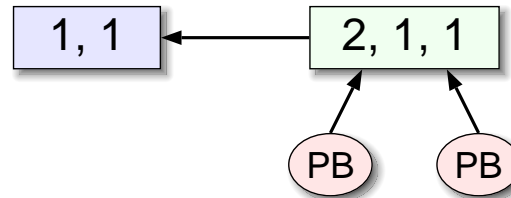
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  - essentially the reverse process to setting up parallel processes, except that for occam- $\pi$  (not MCSP) individual process 'PB's resign when the process terminates, not after the 'PAR' (can be overridden with a compiler flag)
- Implementation currently leaves the disabled set attached to the linked-list of sets, could remove it if we wanted ...

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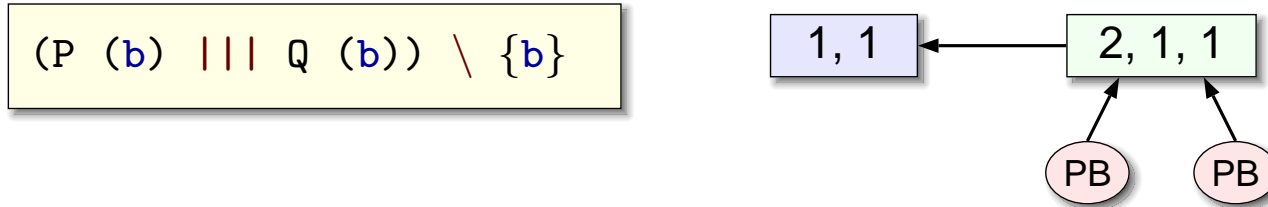
- Straight-forward interleaving (1-of-N) is handled by fixing the sync-count at 1:

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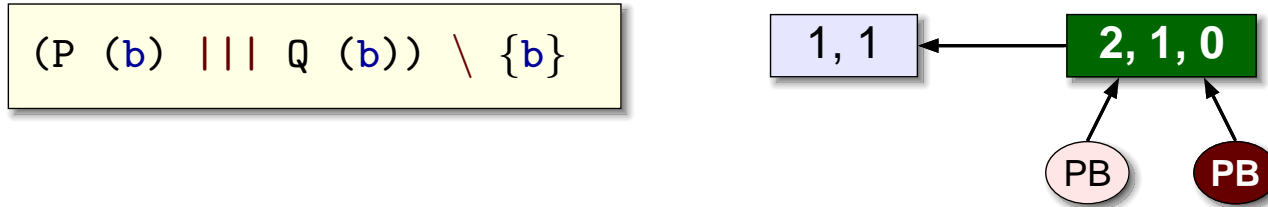
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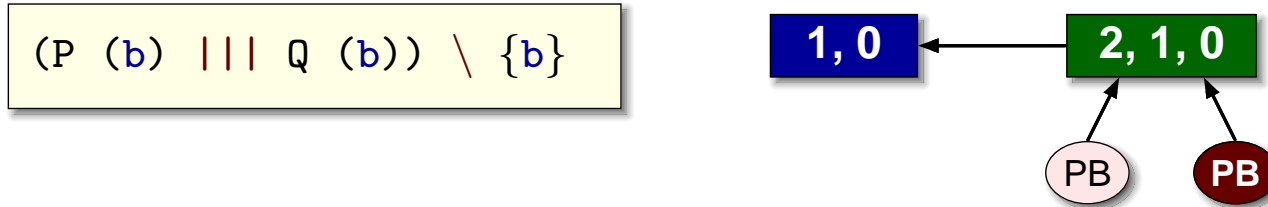
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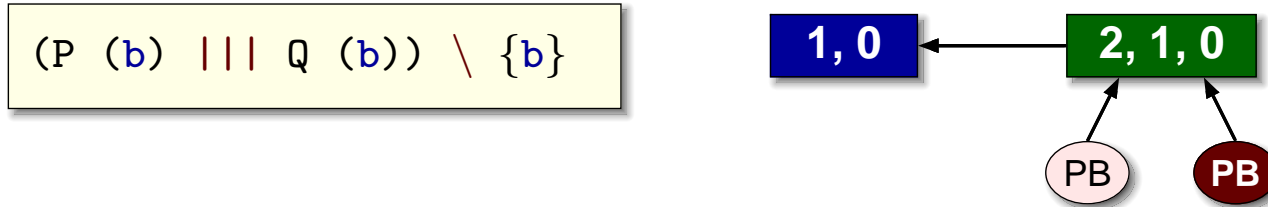
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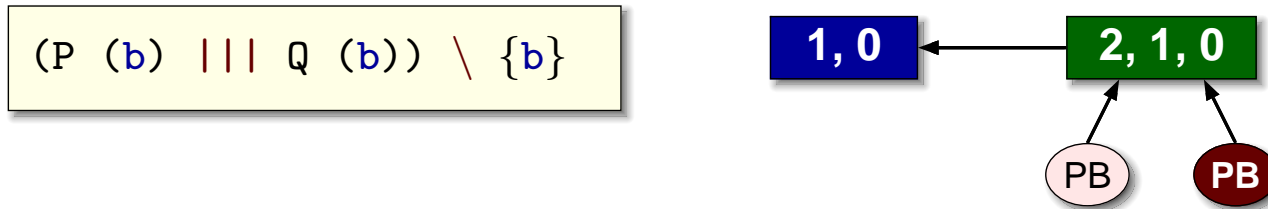
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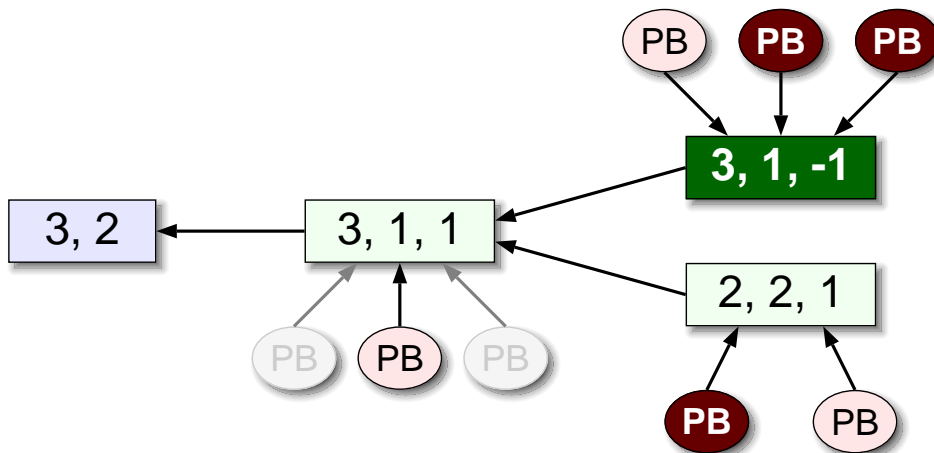
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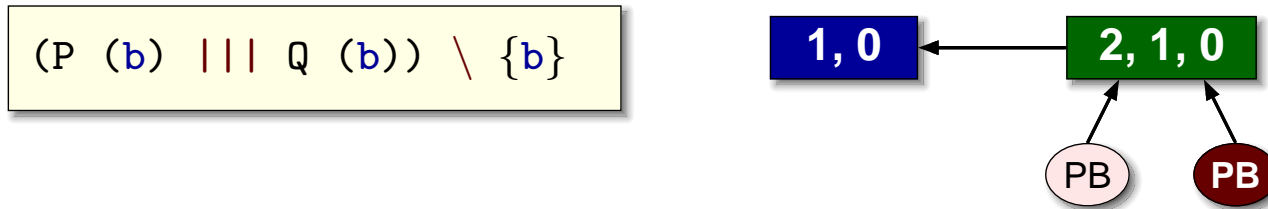


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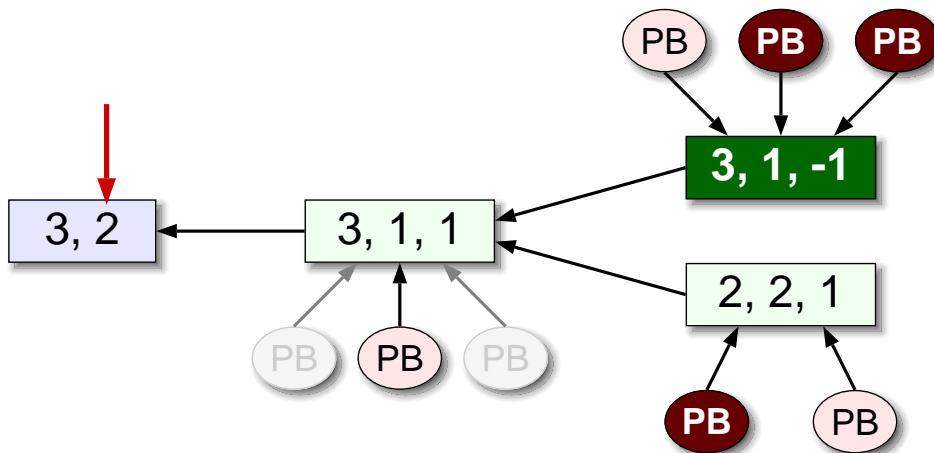
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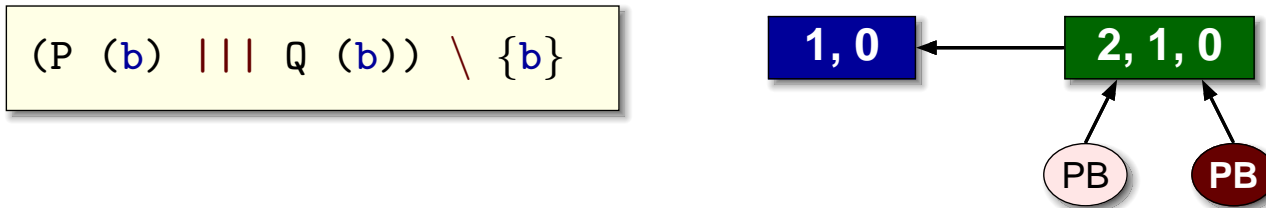
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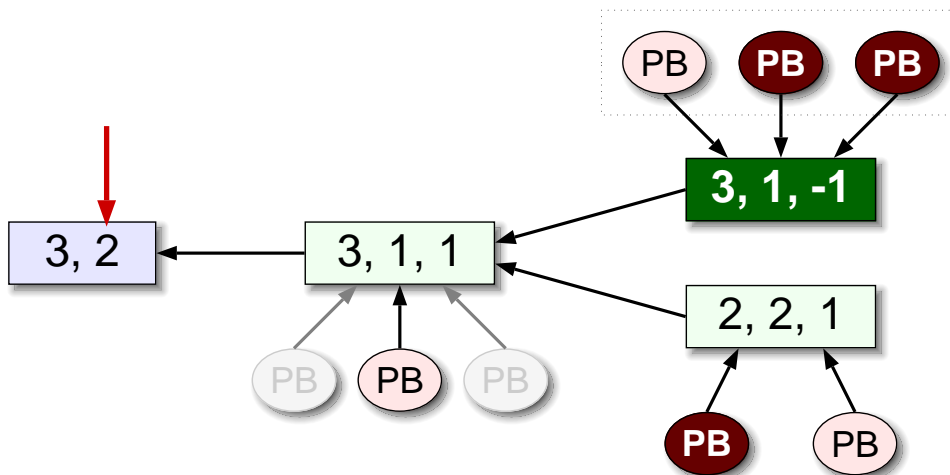


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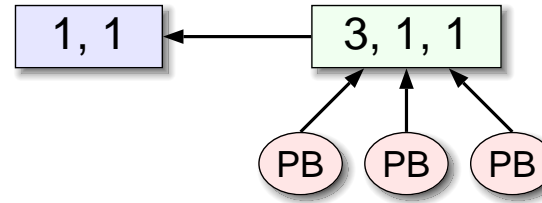
- Two sets left to synchronise
- When complete, only one of the interleaving processes will be resumed (queue implementation provides fairness); set remains ready

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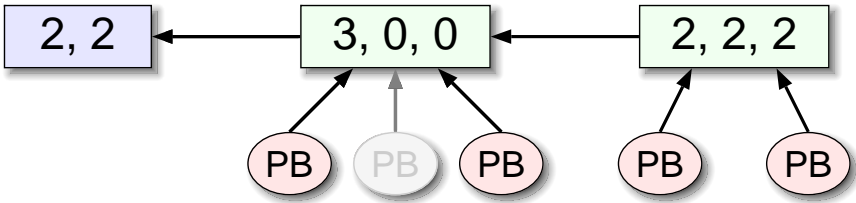


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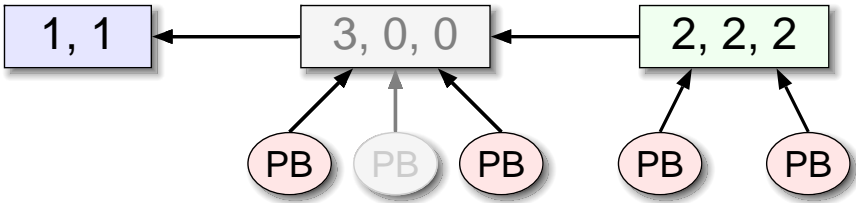


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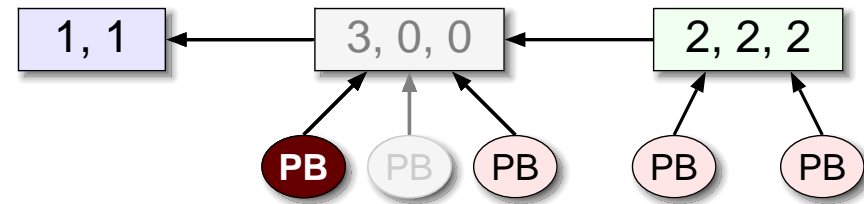


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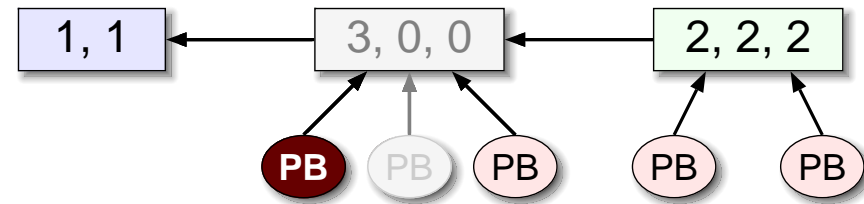
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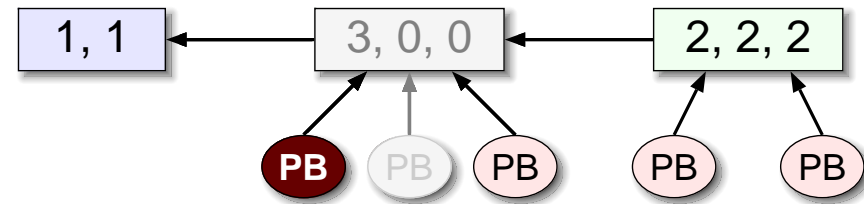
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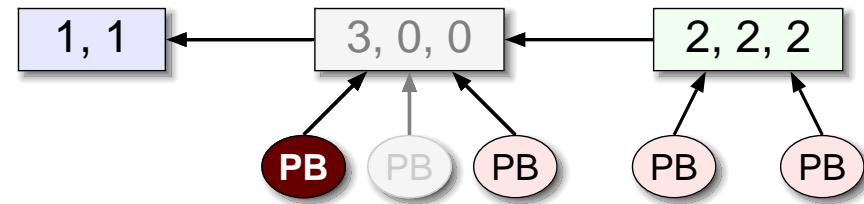
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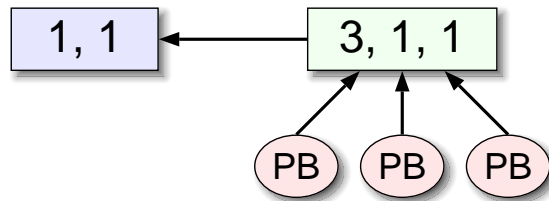


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- An early thought at a solution was to introduce a **missing-count**, separate to sync-count, but this breaks down in **M-of-N** interleaving

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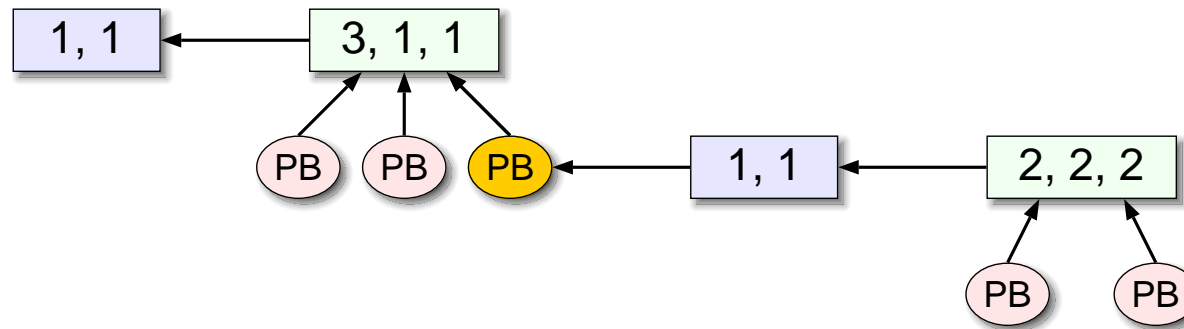
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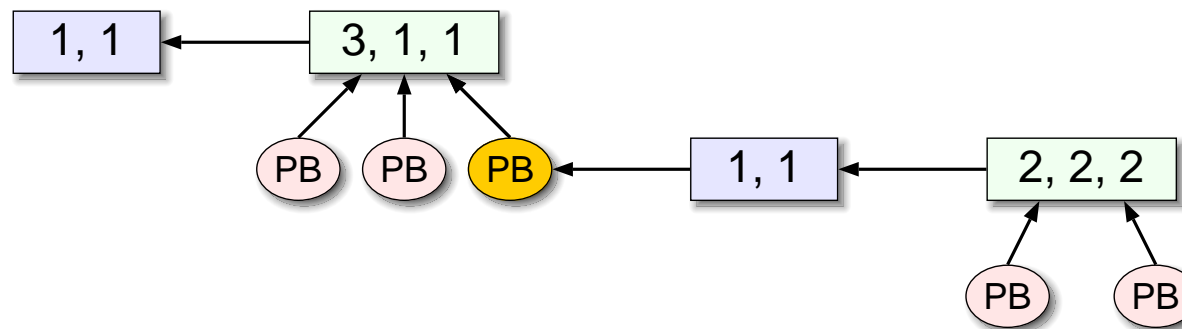
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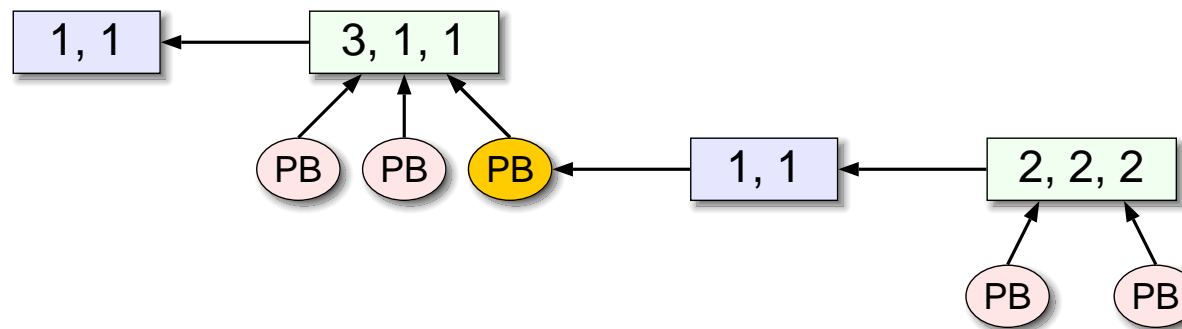
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- Some outstanding issues relating to the **sync-count** when processes resign **in-par** — e.g. when there are only 2 elves left, are they allowed to meet with santa ?

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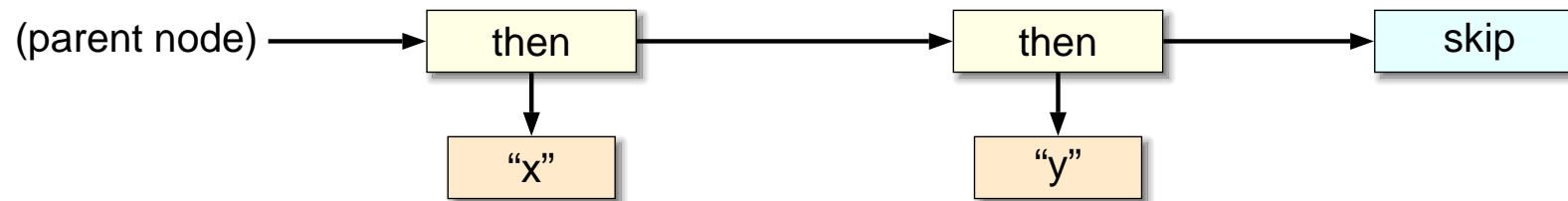
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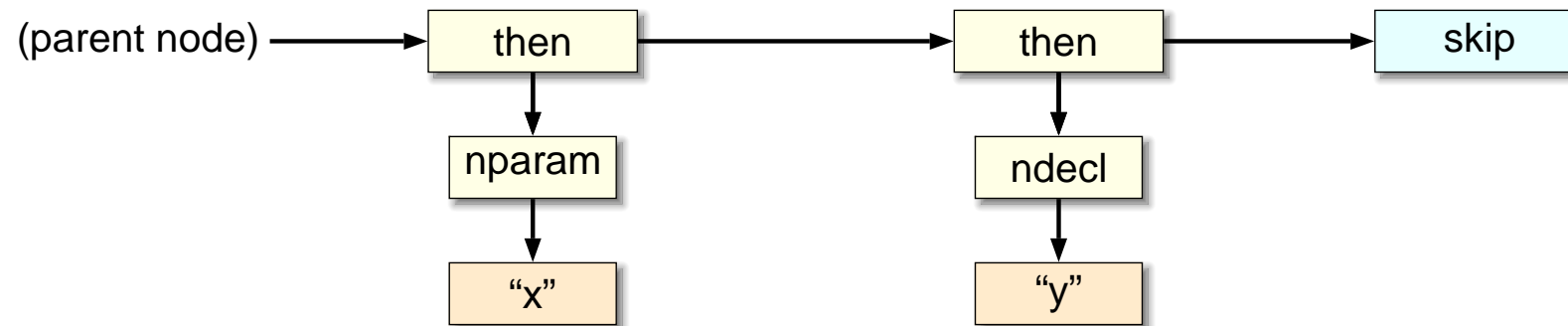
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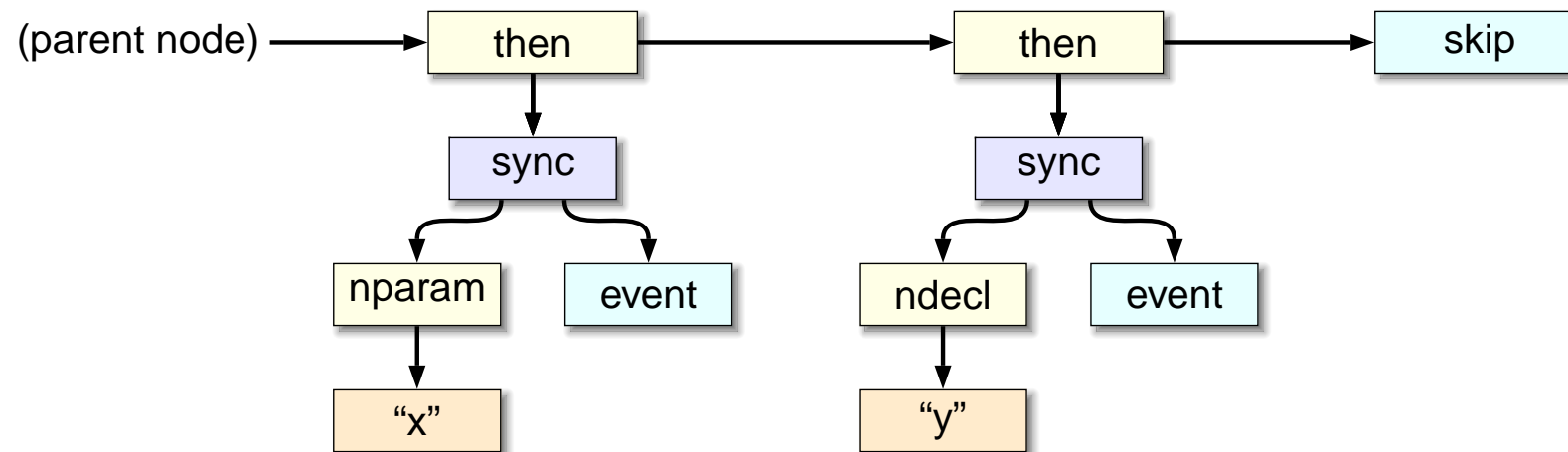
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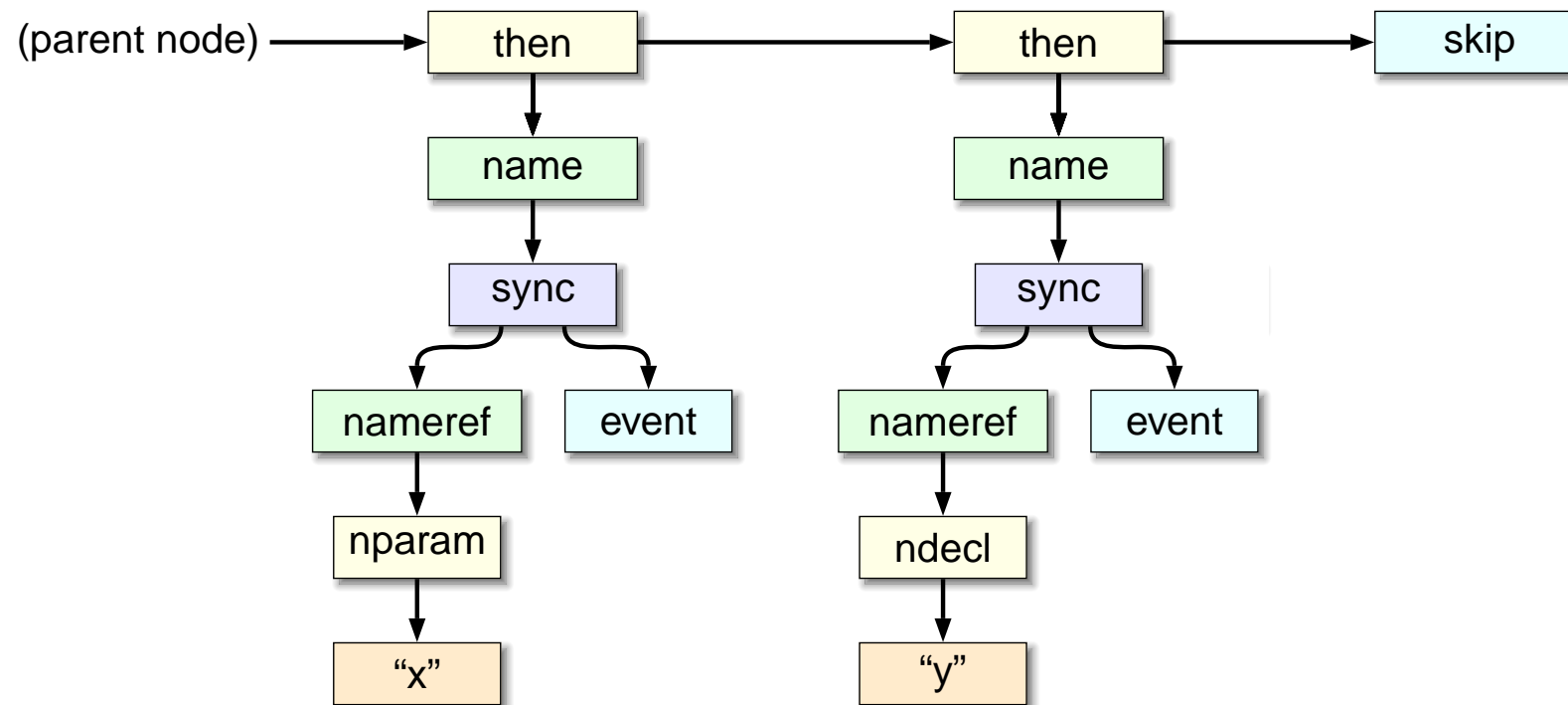
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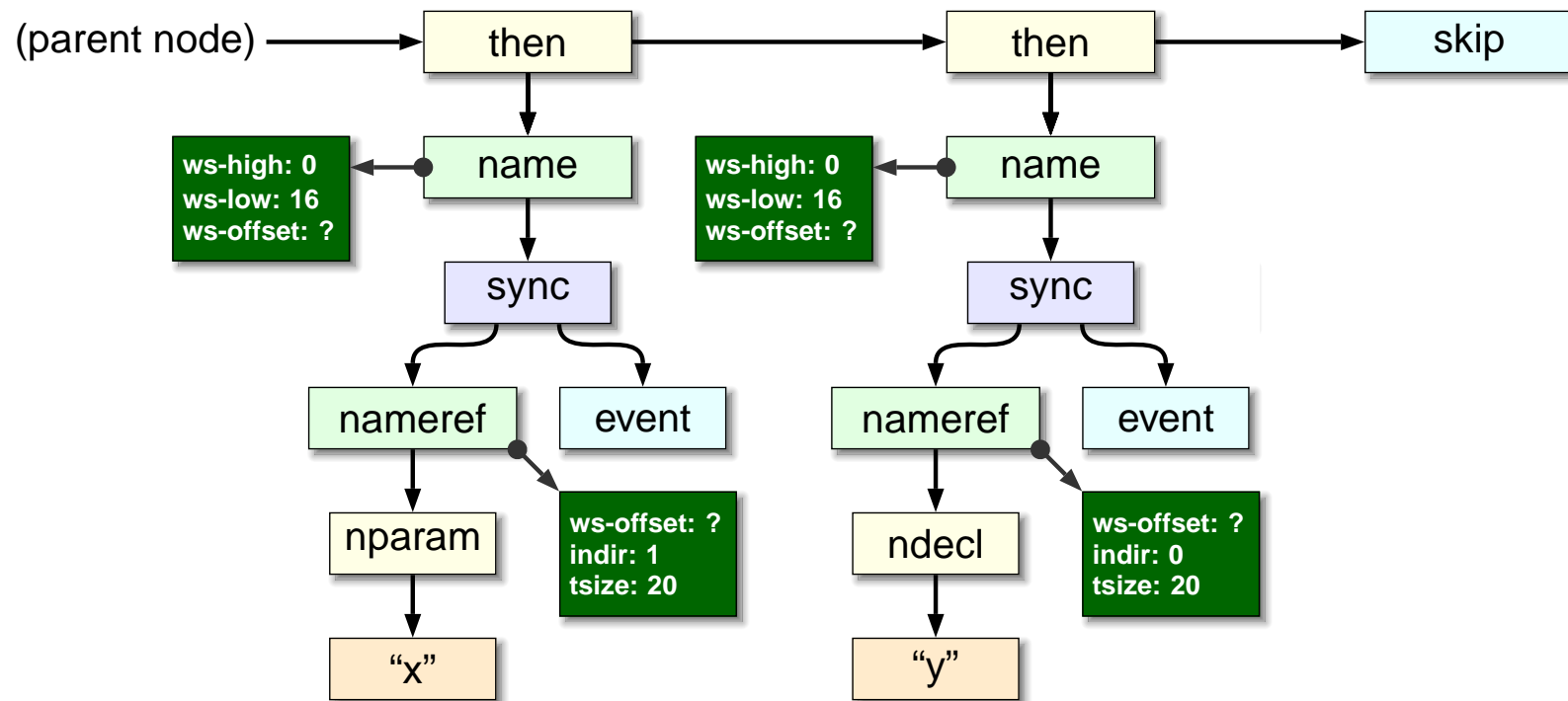
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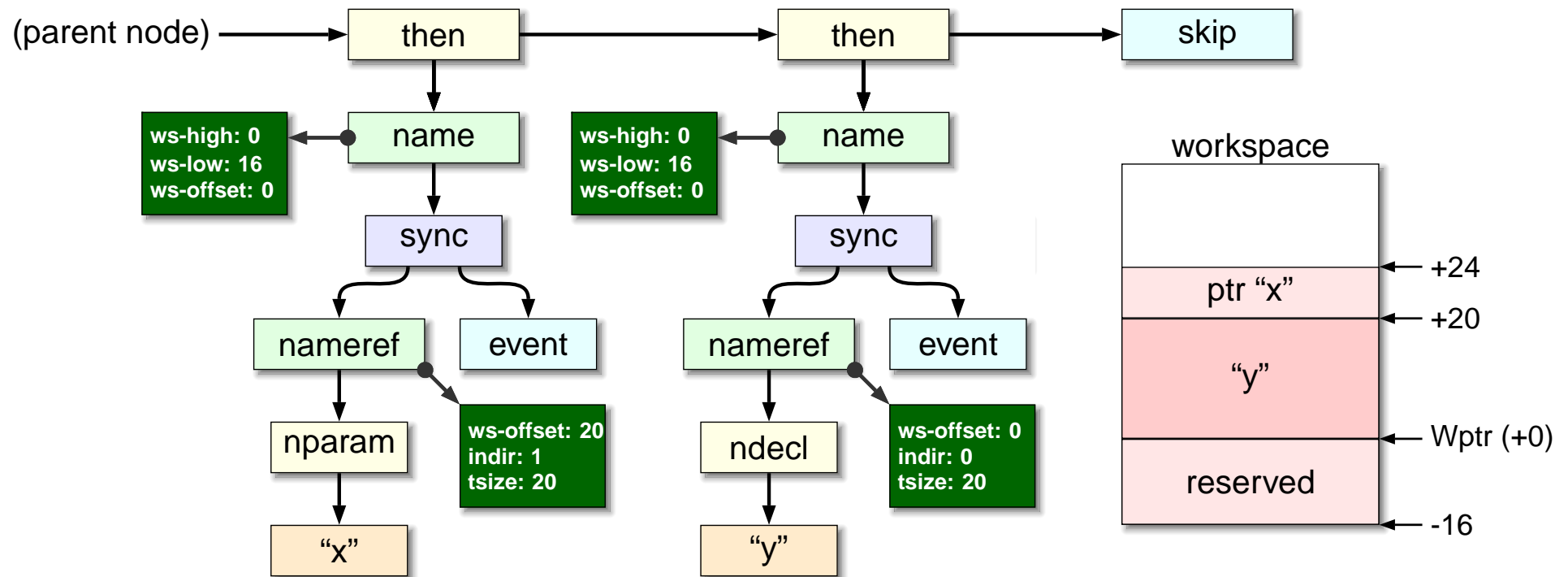
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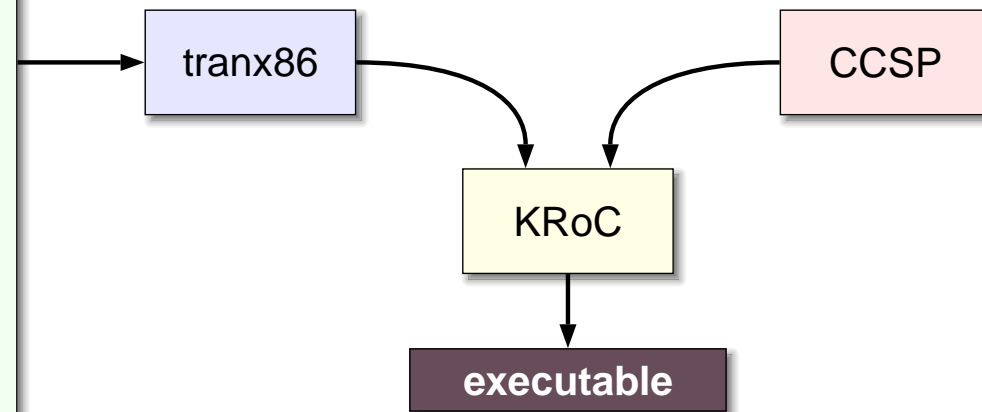
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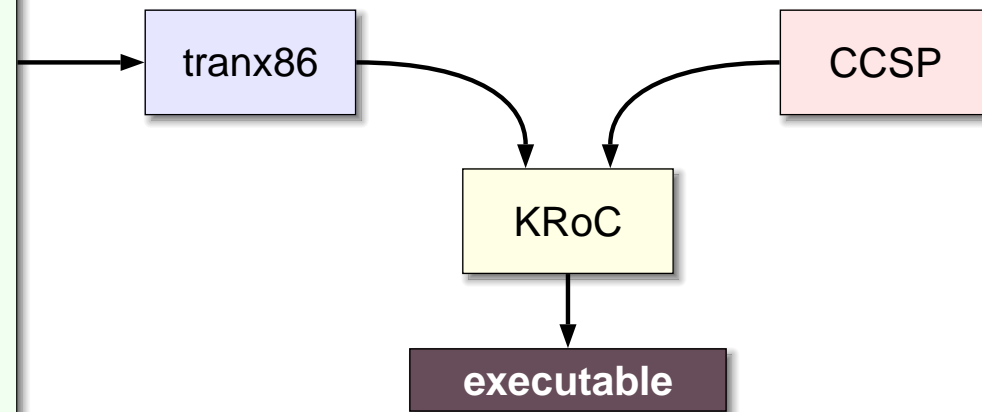
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```
<?xml version="1.0" encoding="iso-8859-1"?>
<nocc:libinfo version="0.1.4">
  <library name="commstime" namespace="">
    <libunit name="commstime.occ">
      <signedhash hashalgo="sha256" value="28373a..." />
      <proc name="CONSUME" language="mcsp"
        target="etc-kroc-unknown">
        <descriptor value="CONSUME(in,report)" />
        <blockinfo allocws="44" adjust="12" />
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      ... 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 ALTs) (using Welch's algorithm with dynamic wait-queue allocation)

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- ▶ The compiler currently manages most **simple** MCSP programs
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- ▶ Items for future consideration:
  - different **environments** — e.g. for graphical visualisations
  - adjustment of the syntax for FDR compatibility