EENG 426/CPSC 459/ENAS 876
Silicon Compilation

Single-variable register

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Single variable register

Single-variable register:

$$*[[\overline{P} \longrightarrow P?x \;[]\; \overline{Q} \longrightarrow Q!x]]$$

The process stores one bit of information in local variable x, which can be read or written.
The environment can communicate on P or Q in any order, but mutual exclusion among the two communication actions is guaranteed.

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Handshaking expansion

Handshaking expansion:

$$*[[pti \vee pfi \longrightarrow [pti \longrightarrow x\uparrow \;[]\; \neg pti \longrightarrow x\downarrow]; po\uparrow; [\neg pti \wedge \neg pfi]; po\downarrow \;[]\; qi \longrightarrow [x \longrightarrow qto\uparrow [] \neg x \longrightarrow qfo\uparrow]; [\neg qi]; qto\downarrow, qfo\downarrow]]$$

Passive protocol on both P and Q.

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Handshaking expansion

Write part:

$$*[[pti \longrightarrow x\uparrow \;[]\; pfi \longrightarrow x\downarrow]; po\uparrow; [\neg pti \wedge \neg pfi]; po\downarrow]$$

Production rules:

$$pti \mapsto x\uparrow \qquad pti \wedge x \vee pfi \wedge \neg x \mapsto po\uparrow$$
$$pfi \mapsto x\downarrow \qquad \neg pti \wedge \neg pfi \mapsto po\downarrow$$

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Handshaking expansion

Read part:

$*[[x \wedge qi \longrightarrow qto\uparrow [] \neg x \wedge qi \longrightarrow qfo\uparrow]; \quad [\neg qi]; qto\downarrow, qfo\downarrow]$

Production rules:

$$x \wedge qi \mapsto qto\uparrow \qquad \neg qi \mapsto qto\downarrow$$
$$\neg x \wedge qi \mapsto qfo\uparrow \qquad \neg qi \mapsto qfo\downarrow$$

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Dual-rail variables

Problem:

$pti \wedge x \vee pfi \wedge \neg x \mapsto po\uparrow$

We will need x and its inverse to turn this into a CMOS implementable circuit.

Solution: introduce the inverted version of x in the HSE

$$\ldots; x\uparrow; \ldots \quad \triangleright \quad \ldots; u\downarrow; v\uparrow; \ldots$$
$$\ldots; x\downarrow; \ldots \quad \triangleright \quad \ldots; v\downarrow; u\uparrow; \ldots$$

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Dual-rail variables

Write part:

$*[[pti \longrightarrow u\downarrow; v\uparrow \; [] pfi \longrightarrow v\downarrow; u\uparrow]; po\uparrow; [\neg pti \wedge \neg pfi]; po\downarrow]$

$$pti \mapsto u\downarrow \qquad pti \wedge v \vee pfi \wedge u \mapsto po\uparrow$$
$$pfi \mapsto v\downarrow \qquad \neg pti \wedge \neg pfi \mapsto po\downarrow$$
$$\neg pfi \wedge \neg u \mapsto v\uparrow$$
$$\neg pti \wedge \neg v \mapsto u\uparrow$$

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Dual-rail variables

Read part:

$*[[v \wedge qi \longrightarrow qto\uparrow [] u \wedge qi \longrightarrow qfo\uparrow]; \quad [\neg qi]; qto\downarrow, qfo\downarrow]$

$$v \wedge qi \mapsto qto\uparrow \qquad \neg qi \mapsto qto\downarrow$$
$$u \wedge qi \mapsto qfo\uparrow \qquad \neg qi \mapsto qfo\downarrow$$

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Environment considerations

If the environment can start the next request before the complete handshake is finished:

$\neg po \wedge v \wedge qi \mapsto qto\uparrow$
$\neg po \wedge u \wedge qi \mapsto qfo\uparrow$

$\neg qto \wedge \neg qfo \wedge pti \mapsto u\downarrow$
$\neg qto \wedge \neg qfo \wedge pfi \mapsto v\downarrow$

$\neg qto \wedge \neg qfo \wedge (pti \wedge v \vee pfi \wedge u) \mapsto po\uparrow$

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