EENG 426/CPSC 459/ENAS 876
Silicon Compilation

Single-variable register

Computer Systems Lab

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Single variable register

Single-variable register:

$$
\begin{array}{l}
*[\,[\overline{P} \longrightarrow P?x \\
\quad []\,\overline{Q} \longrightarrow Q!x \\
\,]\,]
\end{array}
$$

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:

$$*[\,[pti \vee pfi \longrightarrow \quad [pti \longrightarrow x\uparrow \;[]\; \neg pti \longrightarrow x\downarrow]\,;\, po\uparrow;$$
$$\qquad [\neg pti \wedge \neg pfi]\,;\, po\downarrow$$

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

Passive protocol on both P and Q.

Handshaking expansion

Write part:

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

Production rules:

$$pti \mapsto x\uparrow \qquad pfi \mapsto x\downarrow$$

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

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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:

$$\begin{array}{ll} x \wedge qi \mapsto qto\uparrow & \neg qi \mapsto qto\downarrow \\ \neg x \wedge qi \mapsto qfo\uparrow & \neg qi \mapsto qfo\downarrow \end{array}$$

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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:

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

$$\begin{aligned} pti &\mapsto u\!\downarrow \\ pfi &\mapsto v\!\downarrow \\ \neg pfi \wedge \neg u &\mapsto v\!\uparrow \\ \neg pti \wedge \neg v &\mapsto u\!\uparrow \end{aligned}$$

$$\begin{aligned} pti \wedge v \vee pfi \wedge u &\mapsto po\!\uparrow \\ \neg pti \wedge \neg pfi &\mapsto po\!\downarrow \end{aligned}$$

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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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