# Syntax of pure Wagon

| | |
|---|---|
| $\mathbf{G}, \mathbf{H}, ...$ | **Groups** |
| $\quad \mathbf{A}, \mathbf{B}, ...$ | agent groups |
| $\quad \mathbf{V}, \mathbf{W}, ...$ | wall groups (distinct root group: $\top$) |
| $n, m, ...$ | **Names** |
| $\quad a, b, ...$ | agent names |
| $\quad v, w, ...$ | wall names |
| $P ::=$ | **Processes** |
| $\quad w\,[\,P\,]$ | Wall |
| $\quad a\,(M)\,[\,P\,]$ | Agent |
| $\quad (\nu\ \mathbf{G}{:}U)P$ | Restriction (group) |
| $\quad (\nu\ n{:}\mathbf{G})P$ | Restriction (name) |
| $\quad \mathbf{0} \ \mid\ P \mid P \ \mid\ !\,P$ | |

$M ::= \texttt{in}\ w \ \mid\ \texttt{out} \ \mid\ \texttt{dis} \ \mid\ \texttt{get}\ a \ \mid\ \texttt{put}\ a \ \mid\ M\,.\,M$

# Structural Congruence

$$
\begin{array}{lcll}
P \mid (\nu\, n{:}\mathbf{G})Q & \equiv & (\nu\, n{:}\mathbf{G})(P \mid Q) & \text{suppose } n \notin fn(P) \\
P \mid (\nu\, \mathbf{G}{:}U)Q & \equiv & (\nu\, \mathbf{G}{:}U)(P \mid Q) & \text{suppose } \mathbf{G} \notin fg(P) \\
w\,[\,(\nu\, n{:}\mathbf{G})P\,] & \equiv & (\nu\, n{:}\mathbf{G})w\,[\,P\,] & \text{suppose } n \neq w \\
w\,[\,(\nu\, \mathbf{W}{:}Y)P\,] & \equiv & (\nu\, \mathbf{W}{:}Y)w\,[\,P\,] & \\
!\,P & \equiv & P \mid !\,P & \\
!\,\mathbf{0} & \equiv & \mathbf{0} & \\
(\nu\, n{:}\mathbf{G})\mathbf{0} & \equiv & \mathbf{0} & \\
(\nu\, \mathbf{G}{:}U)\mathbf{0} & \equiv & \mathbf{0} &
\end{array}
$$

Note that 1) agent group restrictions can't cross walls, 2) all restrictions can't cross agent borders.

# Reduction semantics

## Evaluation contexts

$$\mathbf{E} \ ::= \ - \ \mid \ P \mid \mathbf{E} \ \mid \ (\nu\, n{:}\mathbf{G})\mathbf{E} \ \mid \ (\nu\, \mathbf{G}{:}U)\mathbf{E} \ \mid \ w\,[\,\mathbf{E}\,]$$

## Movements

$$w\,[\,P\,] \mid a\,(\mathtt{in}\ w\,.\,M)\,[\,Q\,] \longrightarrow w\,[\,P \mid a\,(M)\,[\,Q\,]\,]$$

$$w\,[\,P \mid a\,(\mathtt{out}\,.\,M)\,[\,Q\,]\ \,] \longrightarrow w\,[\,P\,] \mid a\,(M)\,[\,Q\,]$$

## Computation

$$a\,(\mathtt{dis})\,[\,P\,] \longrightarrow P$$

$$a\,(\mathtt{get}\ b\,.\,M)\,[\,P\,] \mid b\,(\mathtt{put}\ a)\,[\,Q\,] \longrightarrow a\,(M)\,[\,P \mid Q\,]$$

## Reduction within contexts, up to sc

$$\frac{P \longrightarrow Q}{\mathbf{E}(P) \longrightarrow \mathbf{E}(Q)} \qquad \frac{P \equiv P' \longrightarrow P'' \equiv P'''}{P \longrightarrow P'''}$$

# Expressing choice

$$
\begin{array}{lcl}
\textbf{Context()} & \stackrel{\triangle}{=} & w_1\,[\,]\mid w_2\,[\,]\mid w_3\,[\,]\mid - \\
e := w_i & \stackrel{\triangle}{=} & e\,(\texttt{get}\ \mathit{case}\,.\,\texttt{in}\ w_i\,.\,\texttt{dis})\,[\,] \\
\texttt{case}_3\ e\ \texttt{of} & \stackrel{\triangle}{=} & (\nu\ k : \mathbf{C})(\ \mathit{case}\,(\texttt{put}\ e)\,[\,\mathit{cnt}\,(\texttt{get}\ k\,.\,\texttt{out}\,.\,\texttt{dis})\,[\ \,]] \\
\quad w_1 : P_1; & & \quad \mid\ \mathit{case}\,(\texttt{in}\ w_1\,.\,\texttt{dis})\,[\,k\,(\texttt{put}\ \mathit{cnt})\,[\,P_1 \mid e := w_1\,]] \\
\quad w_2 : P_2; & & \quad \mid\ \mathit{case}\,(\texttt{in}\ w_2\,.\,\texttt{dis})\,[\,k\,(\texttt{put}\ \mathit{cnt})\,[\,P_2 \mid e := w_2\,]] \\
\quad w_3 : p_3; & & \quad \mid\ \mathit{case}\,(\texttt{in}\ w_3\,.\,\texttt{dis})\,[\,k\,(\texttt{put}\ \mathit{cnt})\,[\,P_3 \mid e := w_3\,]]\ )
\end{array}
$$

e.g. $\textbf{Context}(e := w_2 \mid \texttt{case}_3\ e\ \texttt{of}\ w_1 : P_1;\ w_2 : P_2;\ w_3 : P_3;\,)$

$$\longrightarrow^{12}\simeq \textbf{Context}(e := w_2 \mid P_2)$$

# Encoding $\pi$

$$\begin{array}{lcl}
\mathbf{fwd}(u) & \triangleq & !\,route\,(\mathtt{get}\ route\,.\,\mathtt{out}\,.\,\mathtt{in}\ u\,.\,\mathtt{put}\ route)\,[\,]\\
\langle\!\langle(\nu\ n)P\rangle\!\rangle & \triangleq & (\nu\ n{:}\mathbf{N})(\ n\,[\ !\,route\,(\mathtt{get}\ route\,.\,\mathtt{dis})\,[\,]\,]\\
 & & \qquad\qquad \mid\ \langle\!\langle P\rangle\!\rangle\ )\\
\langle\!\langle\overline{u}\langle v\rangle\,.\,P\rangle\!\rangle & \triangleq & route\,(\mathtt{in}\ u\,.\,\mathtt{put}\ route)\\
 & & \qquad\qquad [\ o\,(\mathtt{put}\ i)\,[\,cnt\,(\mathtt{out}\,.\,\mathtt{dis})\,[\,\langle\!\langle P\rangle\!\rangle\,]\,]\mid \mathbf{fwd}(v)\,]\,]\\
\langle\!\langle u(x)\,.\,P\rangle\!\rangle & \triangleq & (\nu\ x{:}\mathbf{X})(\ route\,(\mathtt{in}\ u\,.\,\mathtt{put}\ route)\\
 & & \qquad\qquad\qquad\qquad [\ i\,(\mathtt{get}\ o\,.\,\mathtt{out}\,.\,\mathtt{in}\ x\,.\,\mathtt{dis})\\
 & & \qquad\qquad\qquad\qquad\quad [\ cnt\,(\mathtt{out}\,.\,\mathtt{dis})\,[\,\langle\!\langle P\rangle\!\rangle\,]\,]\,]\\
 & & \qquad\qquad \mid\ x\,[\,]\ )
\end{array}$$

# Wagon - a little more than pure

Idea: agents can know where they are (the wall names where they stay) – out-binding.

Given sets:

(same: groups and names)

$x, y, z$ Variable wall names

$P ::=$ **Processes**

(same)

$M ::= \texttt{in}\ u \mid \texttt{out}(x{:}Y) \mid \texttt{dis} \mid \texttt{get}\ a \mid \texttt{put}\ a \mid M\,.\,M$

$u ::= w \mid x$ **Values**

Note: $\texttt{out} \triangleq \texttt{out}(x : Y)$, where $x$ is chosen fresh.

# Wagon - Reductions

**Evaluation contexts**

(same)

**Movements**

(same for `in` )

$$w\,[\,P \mid a\,(\texttt{out}(x:Y)\,.\,M)\,[\,Q\,]\ ] \longrightarrow w\,[\,P\,] \mid a\,(M)\,[\,Q\{w/x\}\,]$$

**Computation**

(same: `dis`, `get` /`put` )

**Reduction within contexts, up to sc**

(same)

## $\pi$ in Wagon with out-bindings

$$\langle\!\langle (\nu\ n)P \rangle\!\rangle \quad \stackrel{\triangle}{=} \quad (\nu\ n{:}\mathbf{N})(n[\ \ ] \mid \langle\!\langle P \rangle\!\rangle\ )$$

$$\langle\!\langle \overline{u}\langle v\rangle\,.\,P \rangle\!\rangle \quad \stackrel{\triangle}{=} \quad o\,(\texttt{in}\ u\,.\,\texttt{get}\ i\,.\,\texttt{out}\,.\,\texttt{in}\ v\,.\,\texttt{dis})[cnt\,(\texttt{out}\,.\,\texttt{dis})\,[\,\langle\!\langle P \rangle\!\rangle\,]]$$

$$\langle\!\langle u(x)\,.\,P \rangle\!\rangle \quad \stackrel{\triangle}{=} \quad i\,(\texttt{in}\ u\,.\,\texttt{put}\ o)[\ cnt\,(\texttt{out}(x{:}\mathbf{N})\,.\,\texttt{dis})\,[\,\langle\!\langle P \rangle\!\rangle\,]\,]$$

No more redirection walls $x[\mathbf{fwd}(u)]$, very close to the original $\pi$ semantics.

## $D\pi$ in Wagon with out-bindings

Channel $a{:}\mathbf{A}$ at location $l{:}\mathbf{L}$:

$$l[a[\ ]\ |\ P_{thread}\ ]\ |\ N_{network}$$

Migration:

$$\{\!|\mathtt{go}\ l\,.\,P|\!\} \quad \triangleq \quad toLoc\,(\mathtt{out}\,.\,\mathtt{in}\ l\,.\,\mathtt{dis})\,[\,\{\!|P|\!\}\,]$$

Communication:

For passing channel names, it is the same as in $\pi$;

For passing location names, a little tricky but still encodable.

# The encoding

**Networks:**

$$\{\!|\mathbf{0}|\!\} \triangleq \mathbf{0}$$

$$\{\!|N \mid M|\!\} \triangleq \{\!|N|\!\} \mid \{\!|M|\!\}$$

$$\{\!|(\nu\ l)N|\!\} \triangleq (\nu\ l{:}\mathbf{L})(l\,[\,] \mid \{\!|N|\!\})$$

$$\{\!|(\nu_l\ a)N|\!\} \triangleq (\nu\ a{:}\mathbf{A})(toLoc\,(\texttt{in}\ l\,.\,\texttt{dis})\,[\,a\,[\,]\,] \mid \{\!|N|\!\})$$

$$\{\!|l[\![P]\!]|\!\} \triangleq toLoc\,(\texttt{in}\ l\,.\,\texttt{dis})\,[\,\{\!|P|\!\}\,]$$

**Threads:**

$$\{\!|\texttt{stop}|\!\} \triangleq \mathbf{0}$$

$$\{\!|P \mid Q|\!\} \triangleq \{\!|P|\!\} \mid \{\!|Q|\!\}$$

$$\{\!|\,!\,P|\!\} \triangleq\ !\,\{\!|P|\!\}$$

$$\{\!|(\nu\ l)P|\!\} \triangleq (\nu\ l{:}\mathbf{L})(toNet\,(\texttt{out}\,.\,\texttt{dis})\,[\,l\,[\,]\,] \mid \{\!|P|\!\})$$

$$\{\!|(\nu\ a)P|\!\} \triangleq (\nu\ a{:}\mathbf{A})(a\,[\,] \mid \{\!|P|\!\})$$

$$
\begin{aligned}
\{\!\![\mathtt{go}\ u\,.\,P]\!\!\} &\triangleq toLoc\,(\mathtt{out}\,.\,\mathtt{in}\ u\,.\,\mathtt{dis})\,[\,\{\!\![P]\!\!\}\,] \\
\{\!\![\overline{u_{chn}}\langle u_{loc}\rangle P]\!\!\} &\triangleq o(\mathtt{out}(y{:}\mathbf{L})\,.\,\mathtt{in}\ y\,.\,\mathtt{in}\ u_{chn}\,.\,\mathtt{get}\ i \\
&\qquad .\,\mathtt{out}\,.\,\mathtt{out}\,.\,\mathtt{in}\ u_{loc}\,.\,\mathtt{dis})[ \\
&\qquad\quad toLoc\,(\mathtt{out}\,.\,\mathtt{in}\ y\,.\,\mathtt{dis})\,[\,\{\!\![P]\!\!\}\,]] \quad (y \text{ fresh}) \\
\{\!\![\overline{u_{chn}}\langle v_{chn}\rangle P]\!\!\} &\triangleq o(\mathtt{in}\ u_{chn}\,.\,\mathtt{get}\ i\,.\,\mathtt{out}\,.\,\mathtt{in}\ v_{chn}\,.\,\mathtt{dis})[ \\
&\qquad toLoc\,(\mathtt{out}\,.\,\mathtt{dis})\,[\,\{\!\![P]\!\!\}\,]\,] \\
\{\!\![u_{chn}(x_{loc})P]\!\!\} &\triangleq i\,(\mathtt{out}(y{:}\mathbf{L})\,.\,\mathtt{in}\ y\,.\,\mathtt{in}\ u_{chn}\,.\,\mathtt{put}\ o)\,[ \\
&\qquad toLoc\,(\mathtt{out}(x_{loc}{:}\mathbf{L})\,.\,\mathtt{in}\ y\,.\,\mathtt{dis})\,[\,\{\!\![P]\!\!\}\,]\,] \quad (y \text{ fresh}) \\
\{\!\![u_{chn}(x_{chn})P]\!\!\} &\triangleq i(\mathtt{in}\ u_{chn}\,.\,\mathtt{put}\ o)[toLoc\,(\mathtt{out}(x_{chn}{:}\mathbf{A})\,.\,\mathtt{dis})\,[\,\{\!\![P]\!\!\}\,]\,]
\end{aligned}
$$