A graphical calculus for Klaim nets

Joint work

Rocco De Nicola, Gianluigi Ferrari, Ugo Montanari,

Rosario Pugliese, *Emilio Tuosto*

{denicola,pugliese}@dsi.unifi.it, {giangi,ugo,etuosto}@di.unipi.it .

Dipartimento di Sistemi e Informatica[1]

Univerità di Firenze – Italy

Dipartimento di Informatica[2]

Univerità di Pisa – Italy

Plan of the talk

Plan of the talk

- Motivations

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- Klaim overview

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- Hypergraphs overview

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- An example

Motivations

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- ***non-functional properties of systems***

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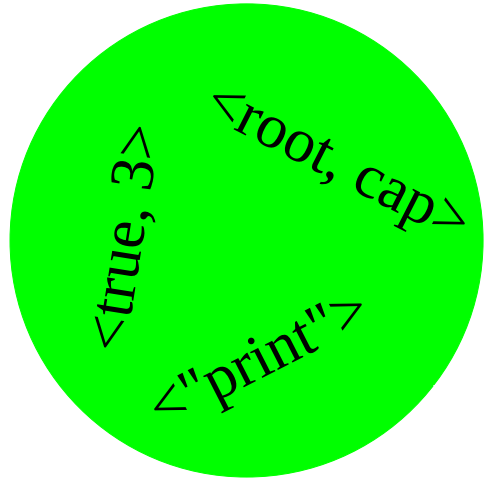
Klaim & Gateways

Klaim: Linda Model



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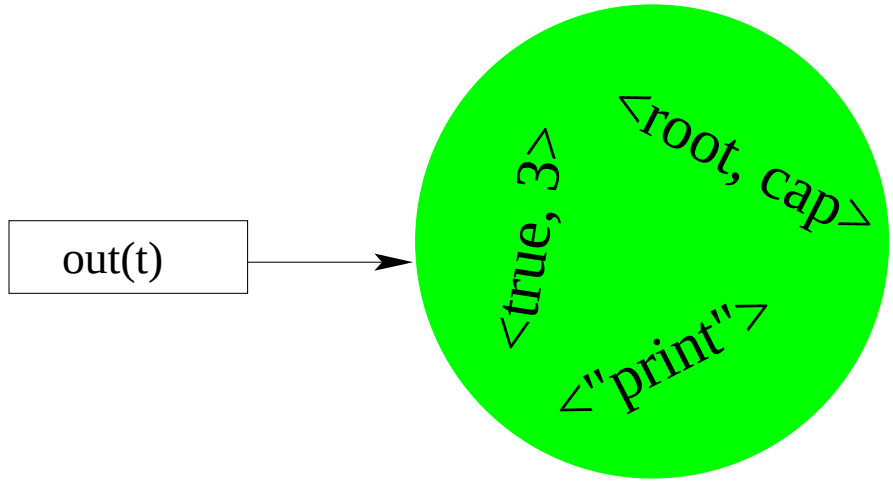

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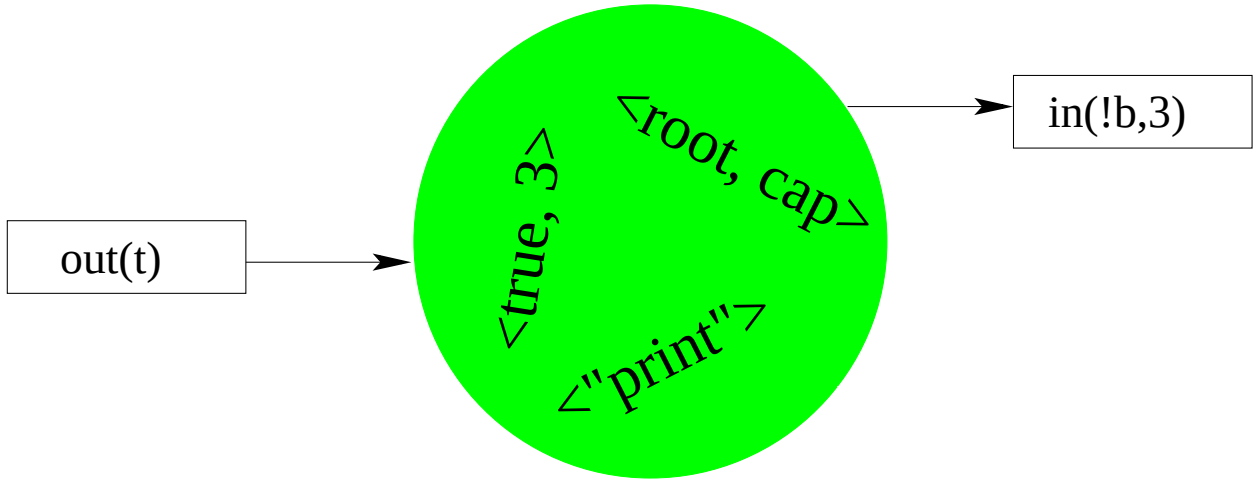

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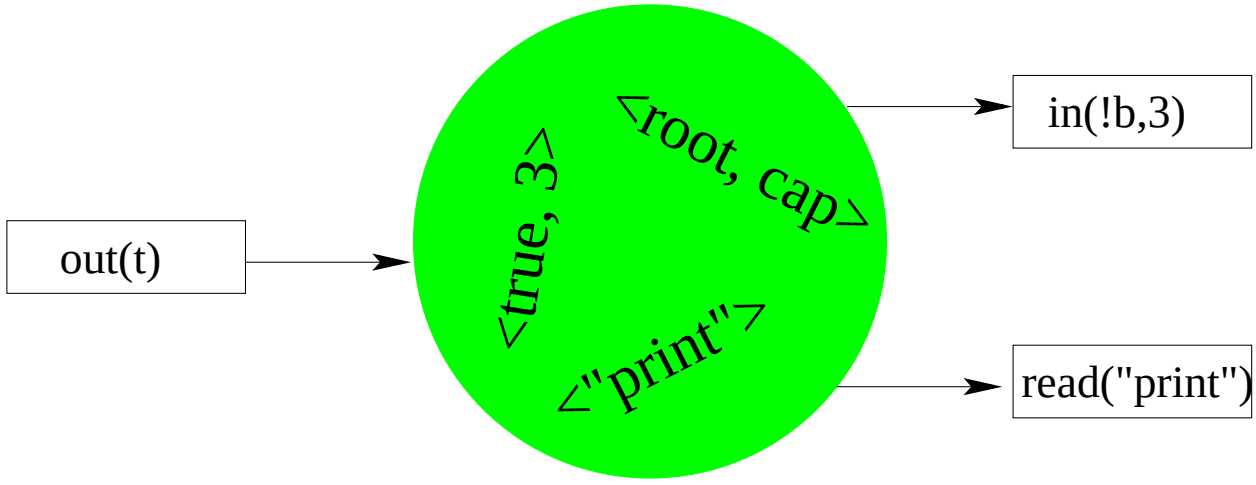

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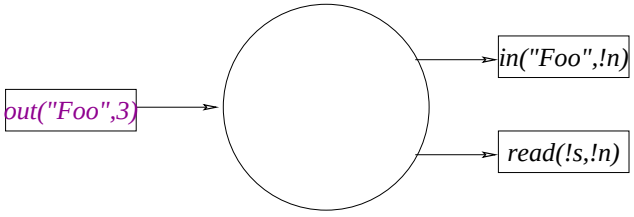

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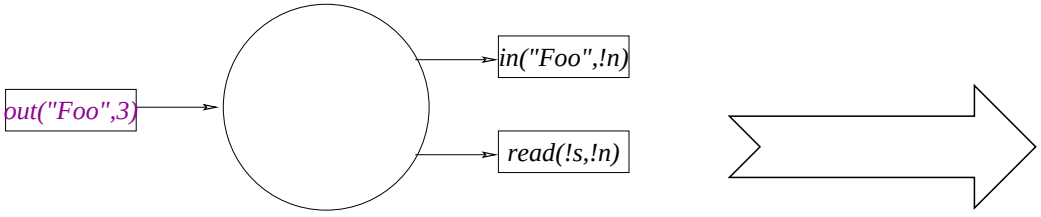

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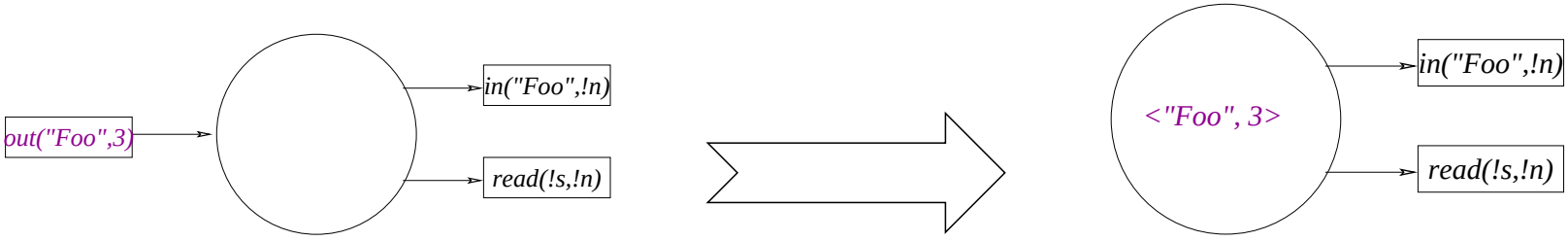

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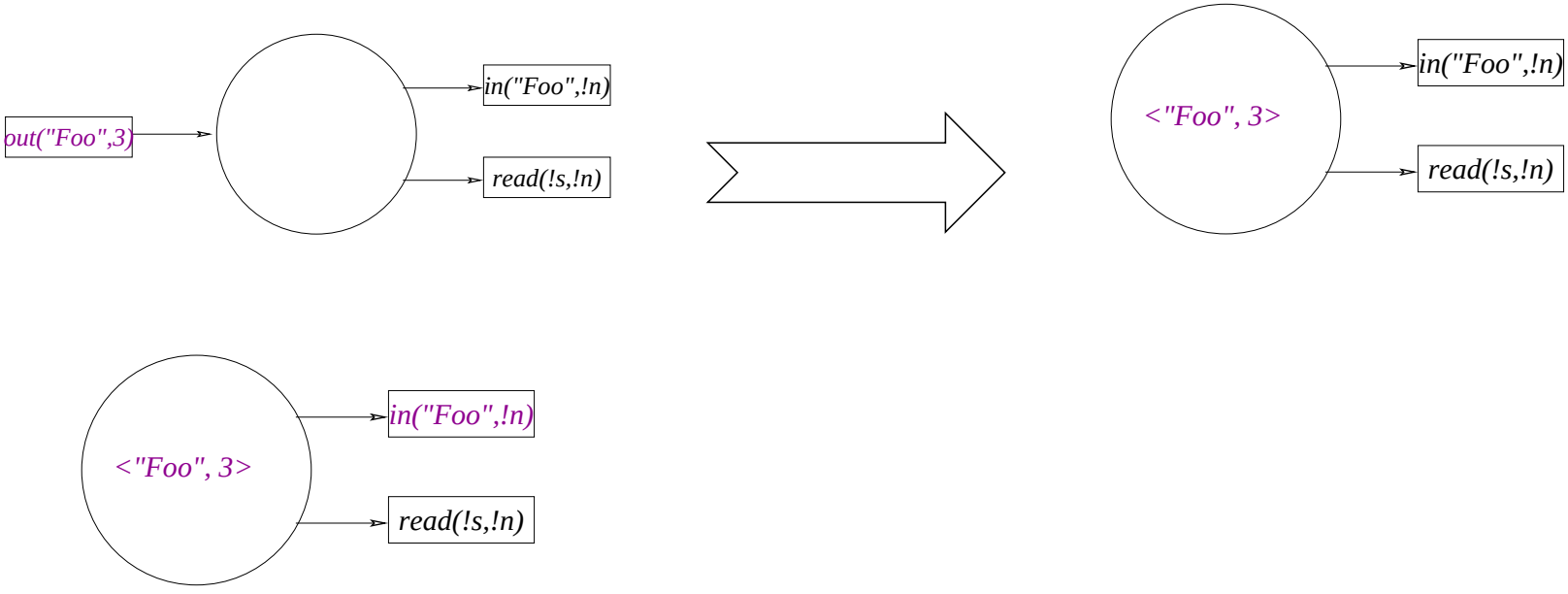

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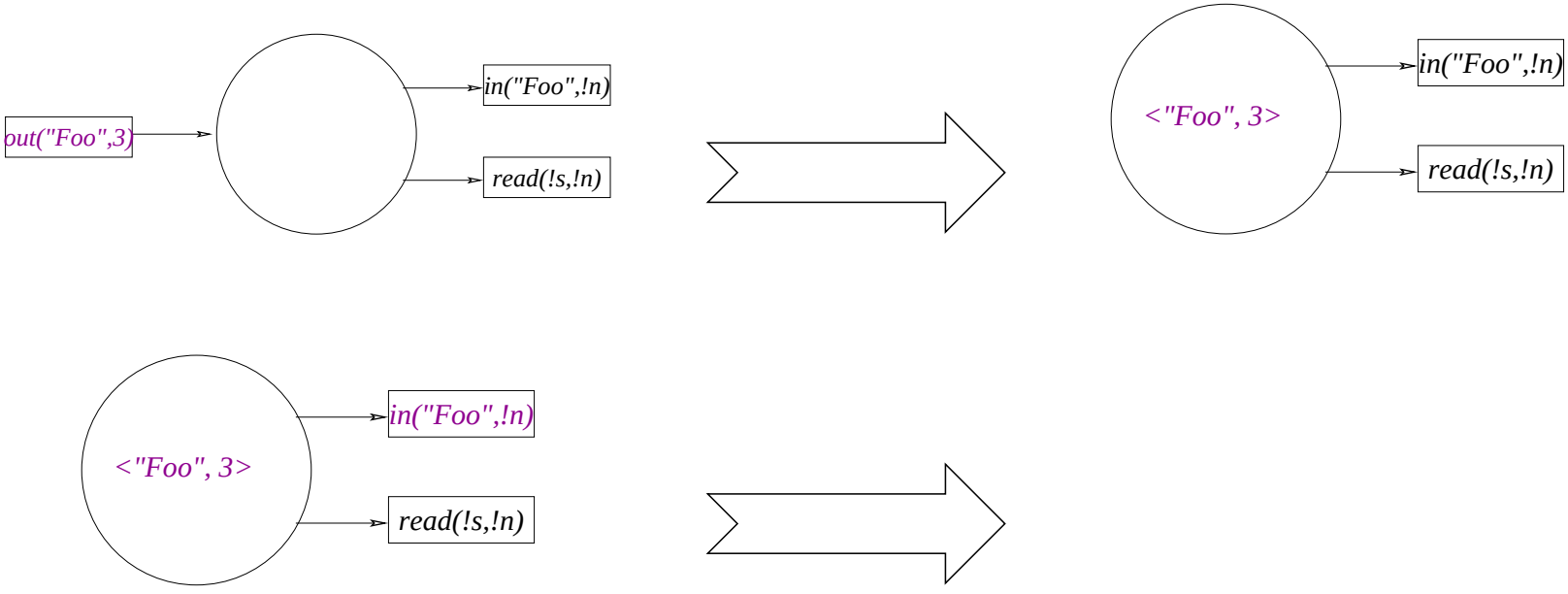

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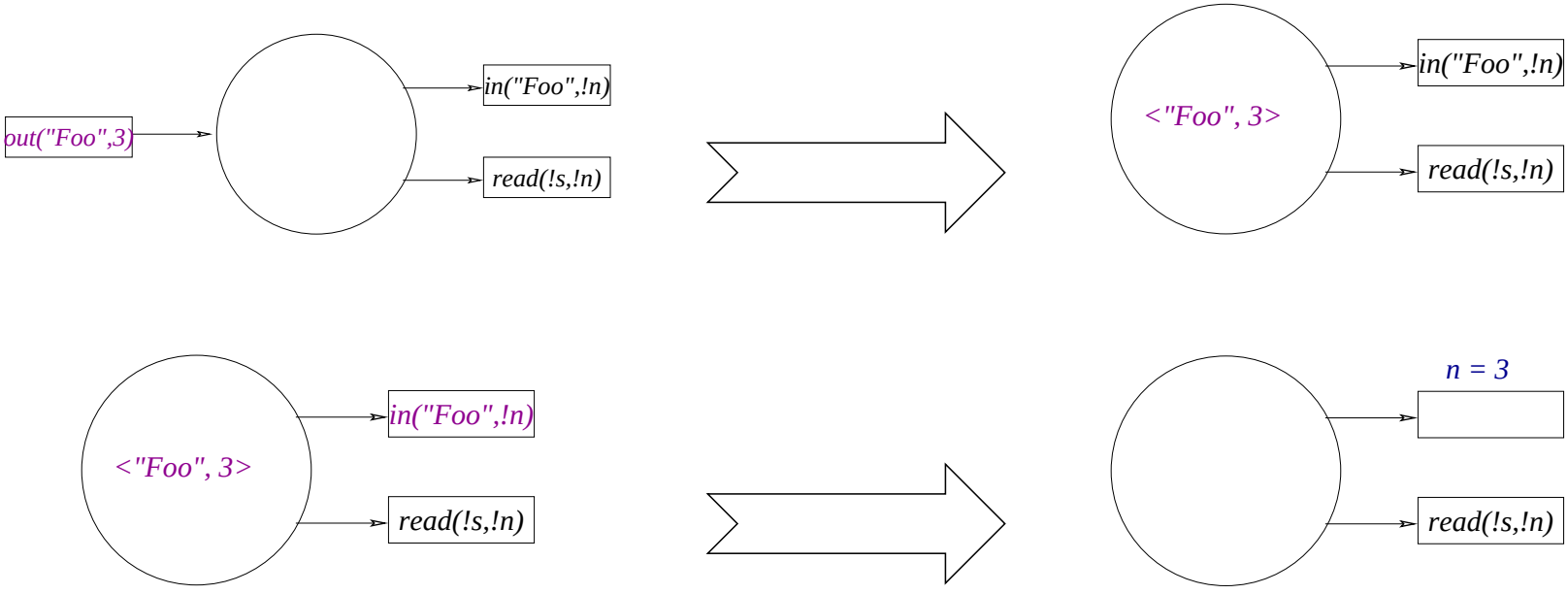

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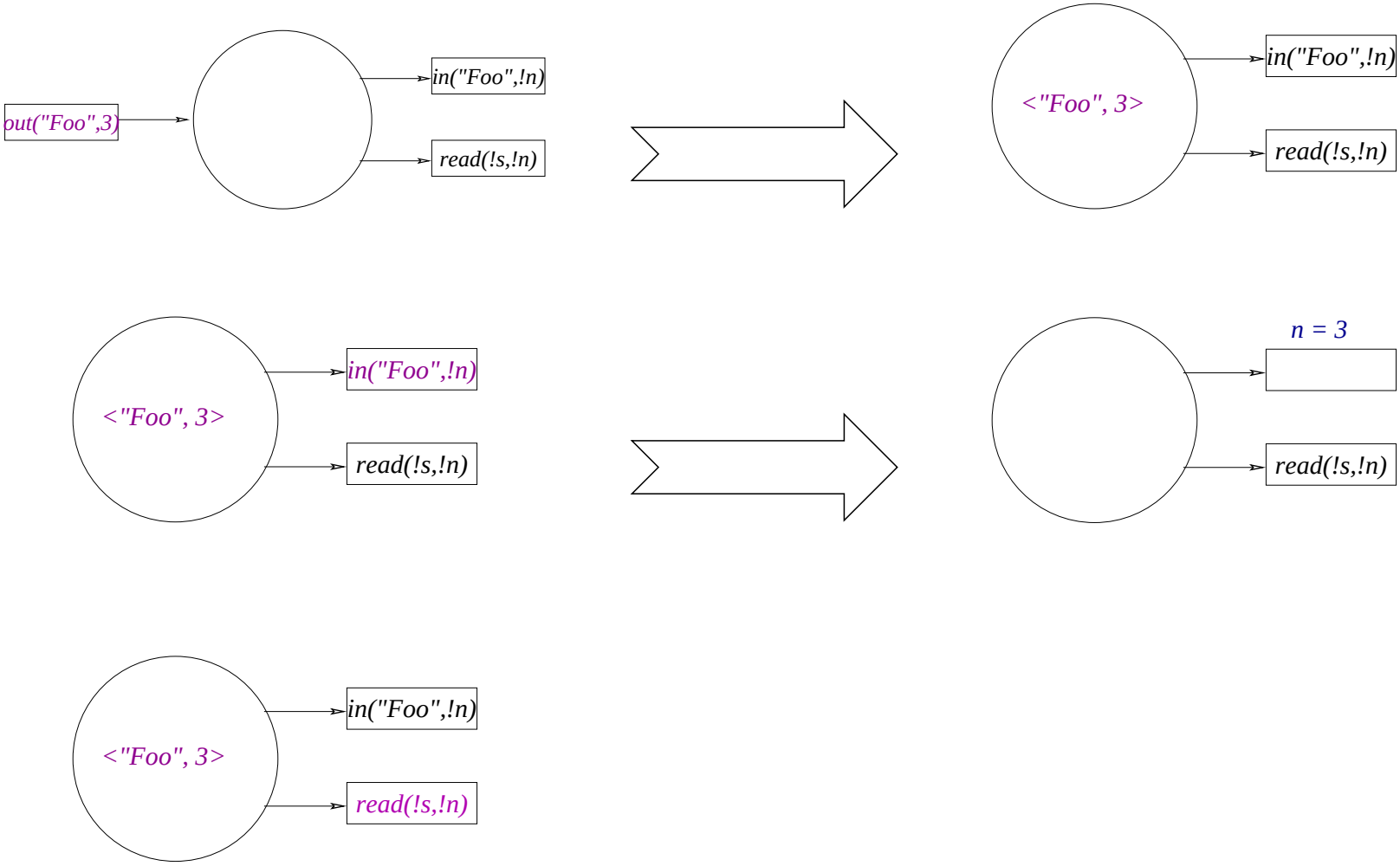

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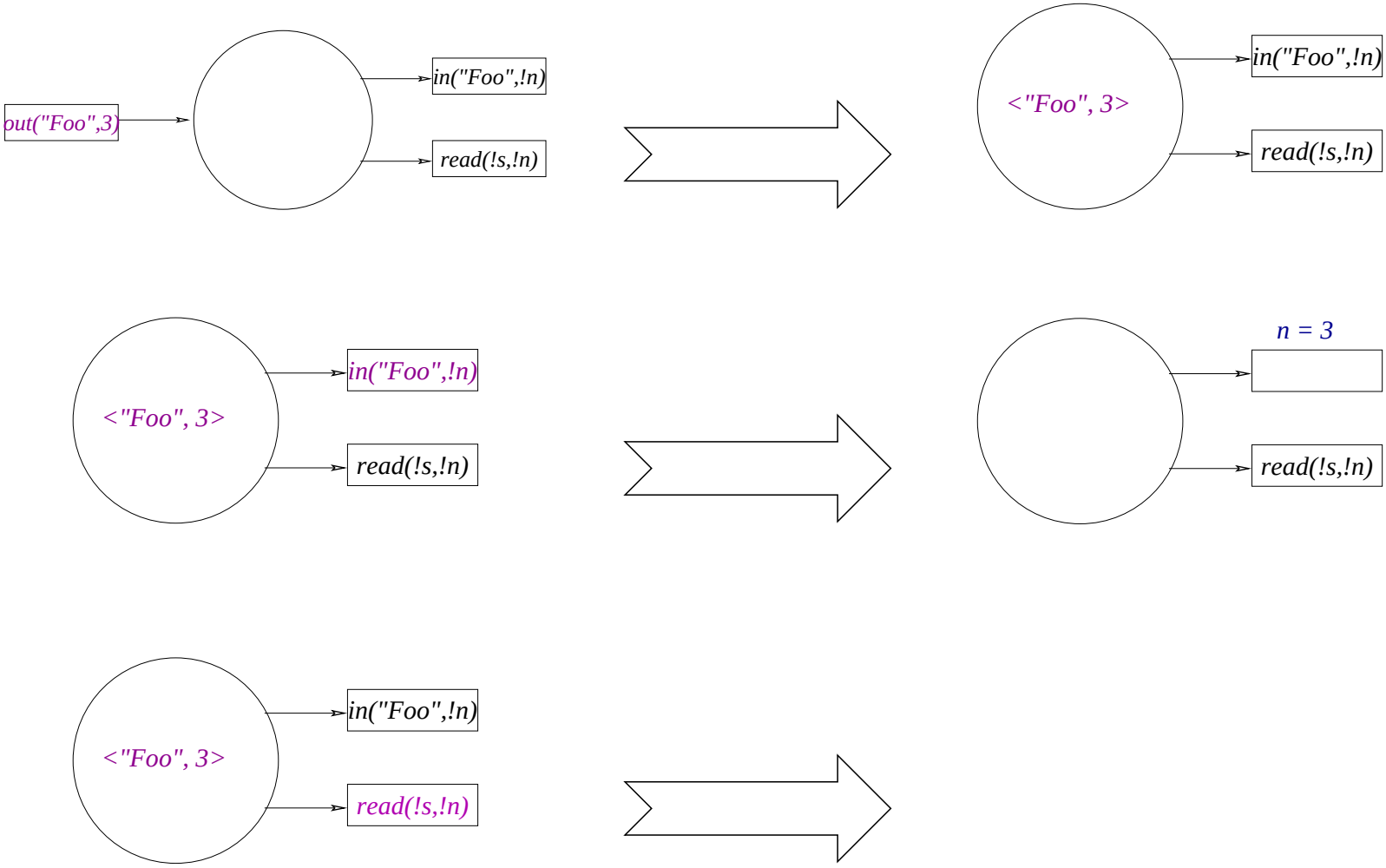

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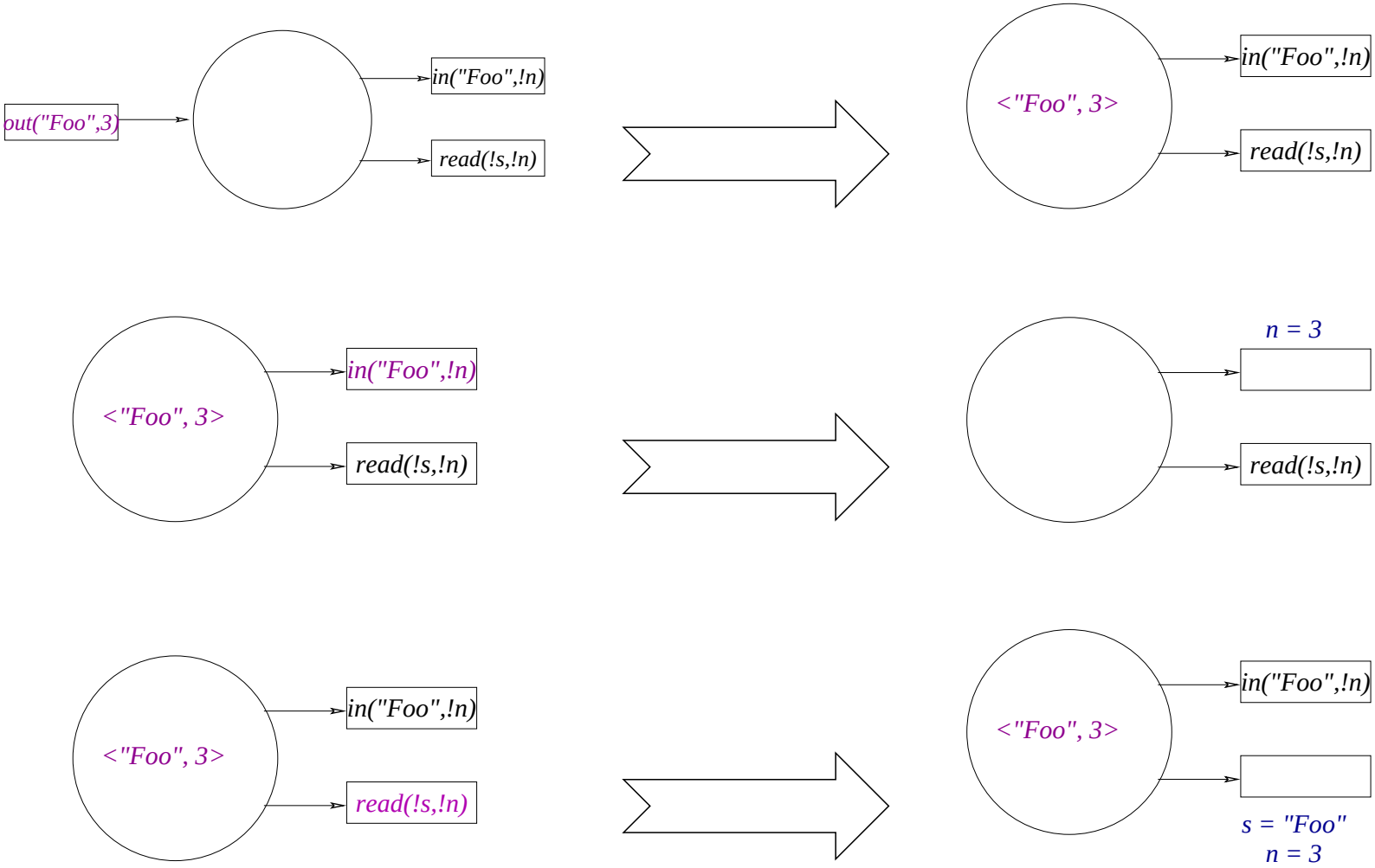

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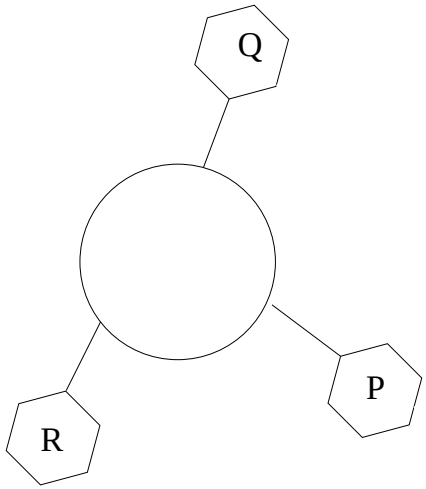

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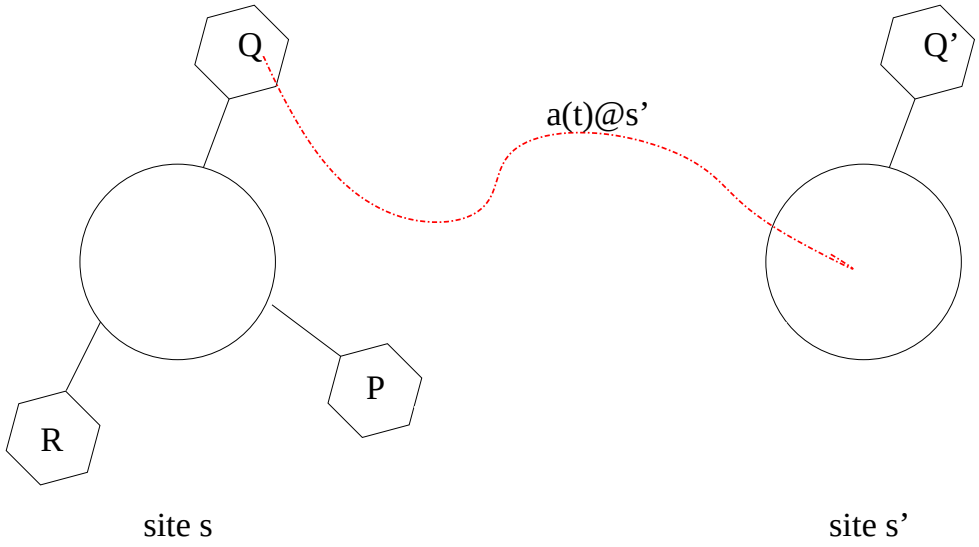

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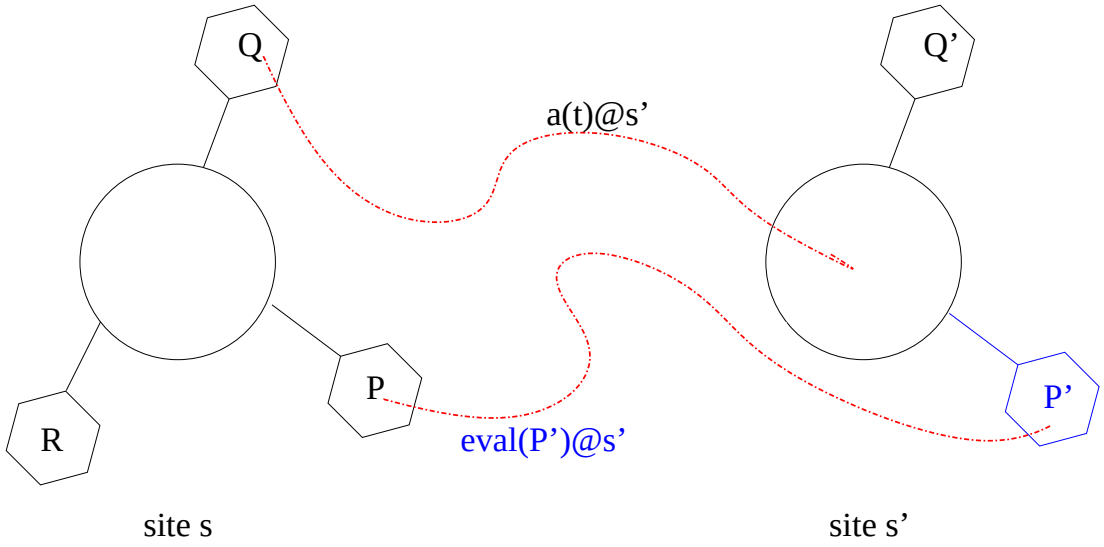

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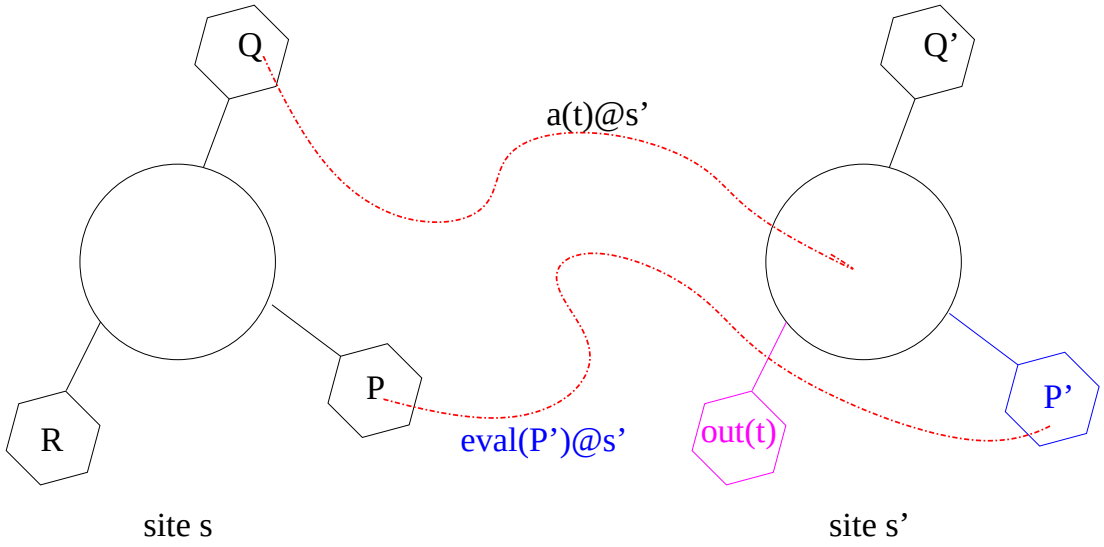

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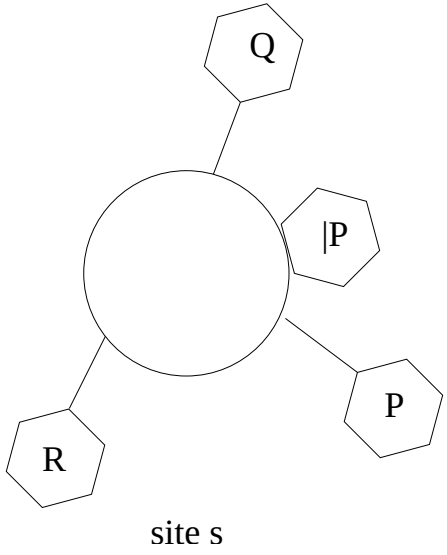

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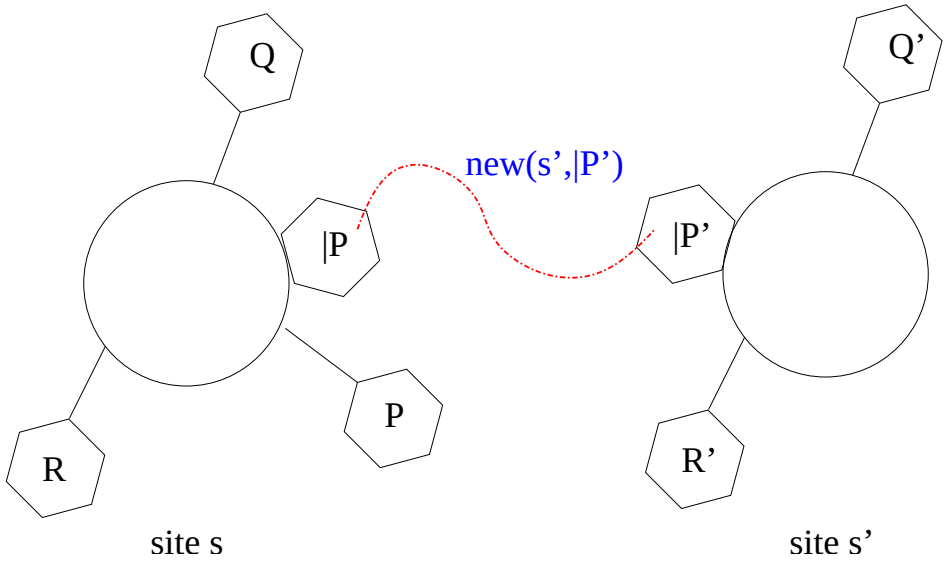

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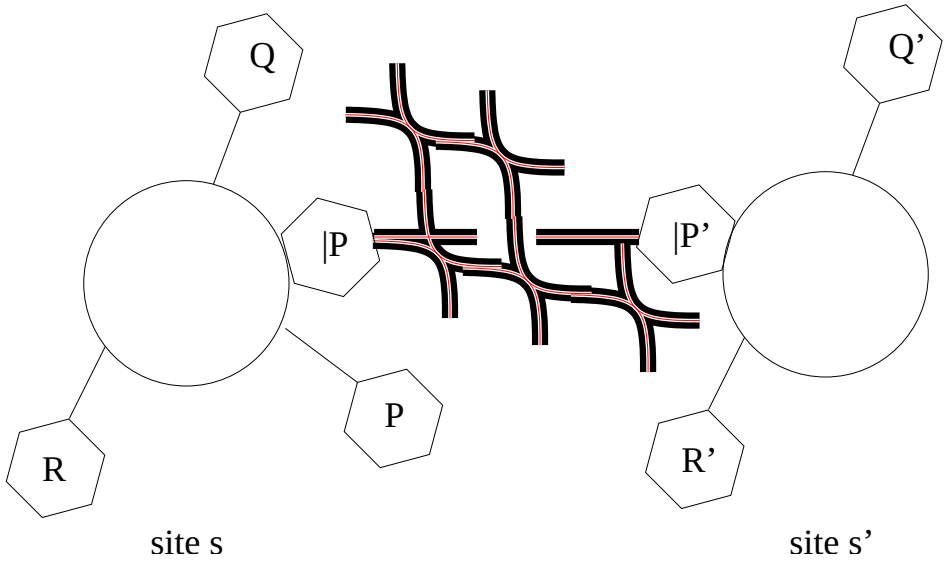

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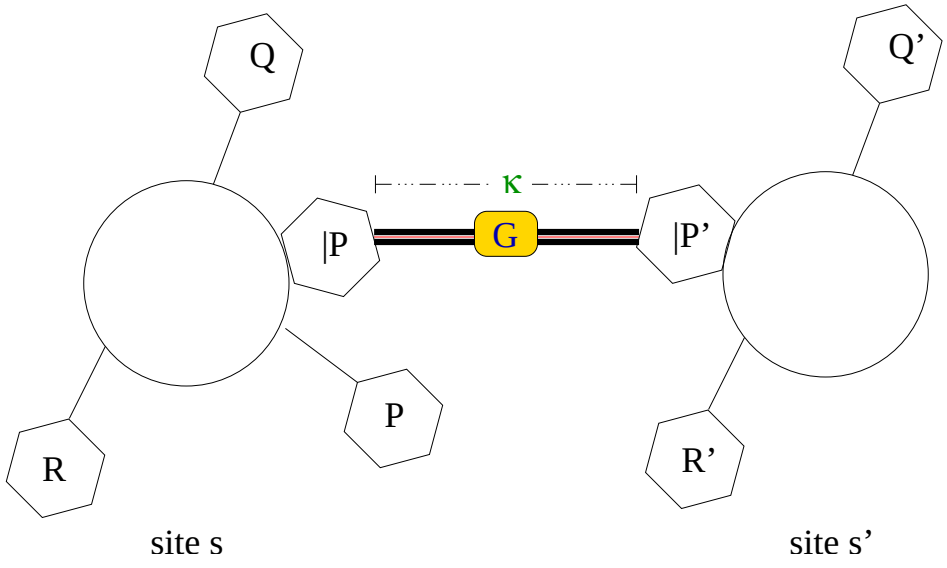

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Operating with costs:

$$\langle c_1, \pi_1 \rangle \otimes \langle c_2, \pi_2 \rangle = \langle c_1 + c_2, \pi_1 \cap \pi_2 \rangle$$

$$\langle c, \pi \rangle \models \mathbf{a} \iff \mathbf{a} \in \pi \qquad (\mathbf{a} \in \{\mathbf{o}, \mathbf{e}, \mathbf{i}, \mathbf{r}\})$$

Klaim Semantics (1)

$$s ::^{I,O} \mathbf{eval}(P)@s'.\mathbb{P} \xrightarrow[s,\top]{\mathbf{e}(s,P,s')} s ::^{I,O} \mathbb{P} \qquad \text{(EVAL)}$$

$$s ::^{I,O} \mathbb{P} \xrightarrow[s,\top]{s::^{I,O}\mathbb{P}} \mathbf{0} \qquad \text{(SITE)}$$

$$\frac{N_1 \xrightarrow[s_1,\kappa]{a} N_1' \quad N_2 \xrightarrow[s_2,\kappa_2]{s_2::^{I\sqcup\langle s_1,\kappa_1\rangle,O}\mathbb{P}} N_2'}{N_1 \parallel N_2 \xrightarrow[s_2,\kappa\otimes\kappa_1]{a} N_1' \parallel N_2' \parallel s_2 ::^{I\sqcup\langle s_1,\kappa_1\rangle,O} \mathbb{P}} \qquad \text{(ENV)}$$

$$\frac{N_1 \xrightarrow[s,\kappa_1]{\mathbf{e}(s_1,P,s_2)} N_1' \qquad N_1' \xrightarrow[s,\kappa_2]{s_2::^{I,O}\mathbb{P}} N_2 \qquad \kappa_1 \otimes \kappa_2 \models \mathbf{e}}{N_1 \rightarrowtail N_2 \parallel s_2 ::^{I,O} P|\mathbb{P}} \qquad \text{(NETEVAL)}$$

Klaim Semantics (2)

$$s_1 ::^{I,O} \mathbf{login}(s_2, \kappa).\mathbb{P} \xrightarrow{\mathbf{lin}(s_1, \kappa, s_2)} s_1 ::^{I, O \sqcup \langle s_2, \kappa \rangle} \mathbb{P} \qquad \text{(LOGIN)}$$

$$s_2 ::^{I,O} \mathbf{accept}(s, \kappa).\mathbb{P} \xrightarrow{\mathbf{acc}(s_2, \kappa, s_1)} s_2 ::^{I \sqcup \langle s_1, \kappa \rangle, O} \mathbb{P}[s_1/s] \qquad \text{(ACCEPT)}$$

$$\frac{N_1 \xrightarrow{\mathbf{lin}(s_1, \kappa, s_2)} N_1' \quad N_1' \xrightarrow{\mathbf{acc}(s_2, \kappa, s_1)} N_2}{N_1 \rightarrowtail N_2} \qquad \text{(NETCONNECT}$$

Klaim: Example

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s & ::\{\langle s',\{\kappa 3\}\rangle\},\{\langle s'',\{\kappa 1\}\rangle\} \quad \mathbf{eval}(P)@s' \\
\| & \\
s'' & ::\{\langle s',\{\kappa 2\}\rangle\},\{\langle s,\{\kappa 1\}\rangle\} \quad \ldots \\
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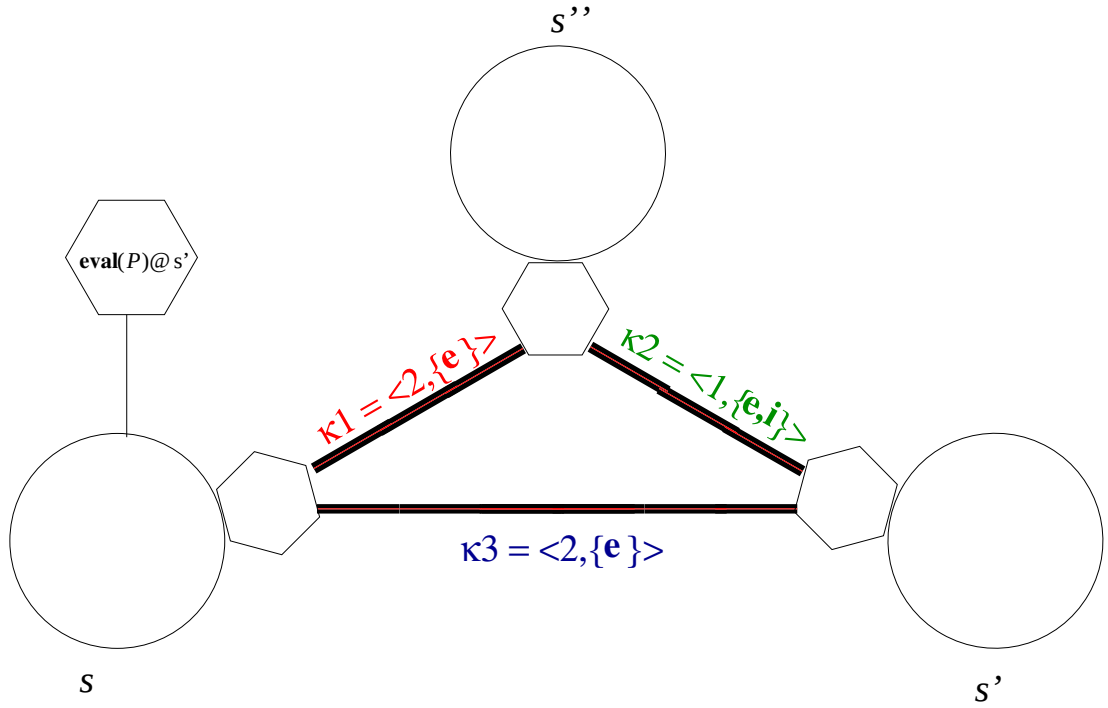

Hypergraphs

Constrained synchronizations

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(Hyper)Graphical calculus: edge replacement

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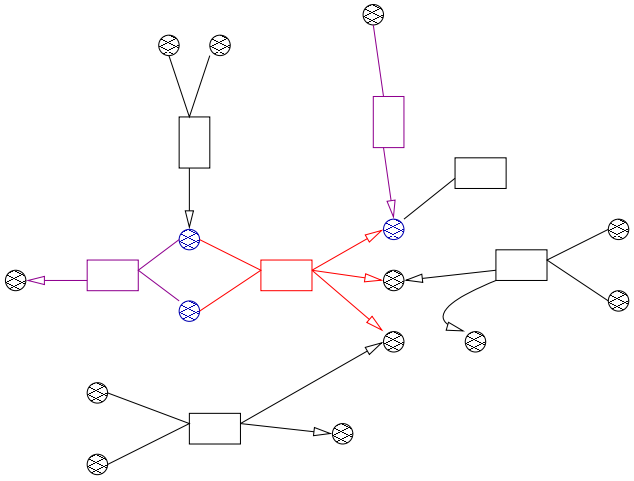

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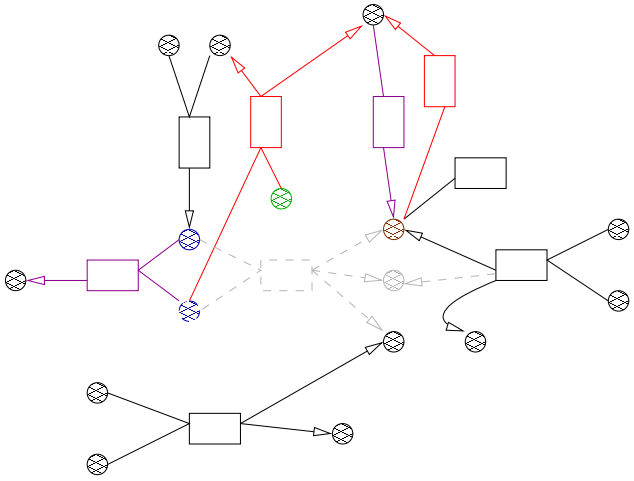

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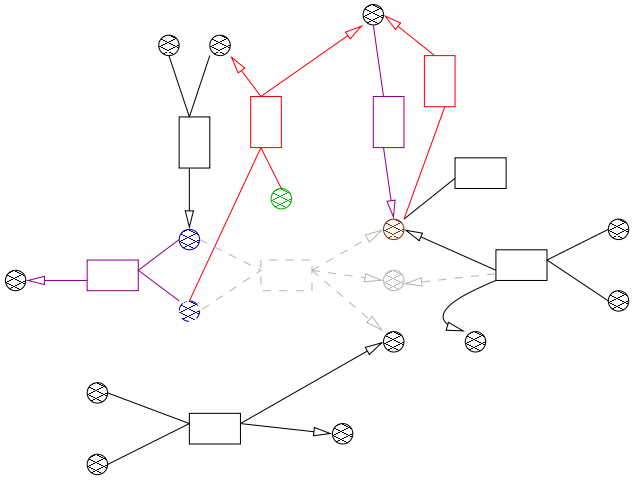

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- New node creation
- Node fusion: mobility model

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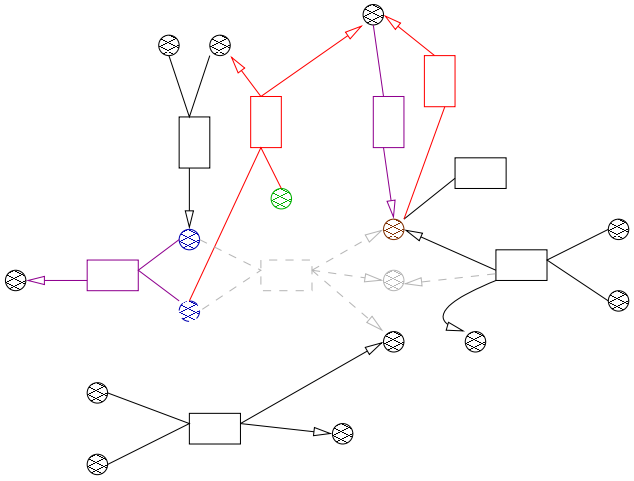

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Benefits:

- Powerful model of system composition (π, π-I, fusion)
- LTS for Ambient (ICTCS 2001)...
- ...and for Klaim
- and its extension to gateways with costs

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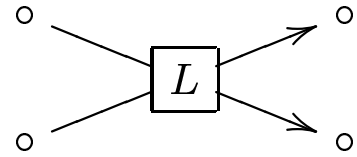

Graphs: Syntax

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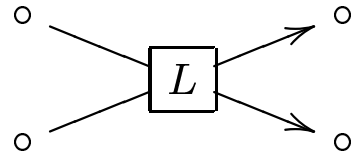

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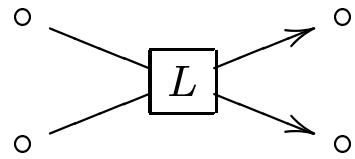

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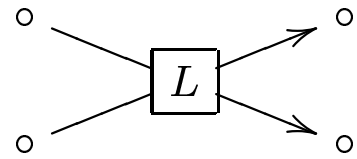

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$$L : 2 \to 1, \quad M : 1 \to 1$$
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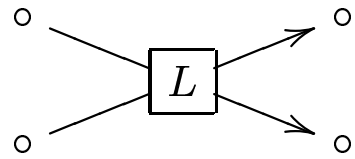

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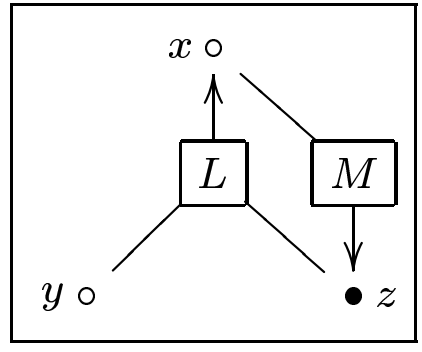

Graphs: Transitions and Productions

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Transitions $\quad \Gamma \vdash G_1 \xrightarrow{\Lambda,\pi} \phi \vdash G_2$

$$\begin{cases} \Lambda : \Gamma \multimap (Act \times \mathcal{N}^*) \\ \pi : \Gamma \to \Gamma, \quad \pi^{-1}(x) \neq \emptyset \Rightarrow x \in \pi^{-1}(x) \\ n(\Lambda) \cap \Gamma \subseteq \pi(\Gamma) \\ \phi = \pi(\Gamma) \cup (n(\Lambda) - \Gamma) \end{cases}$$

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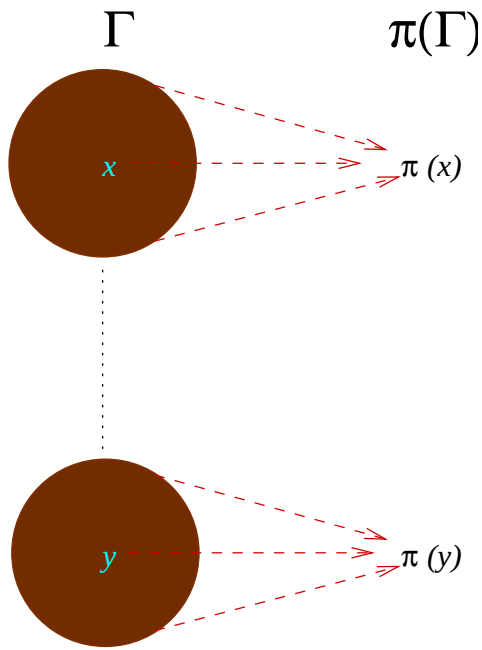

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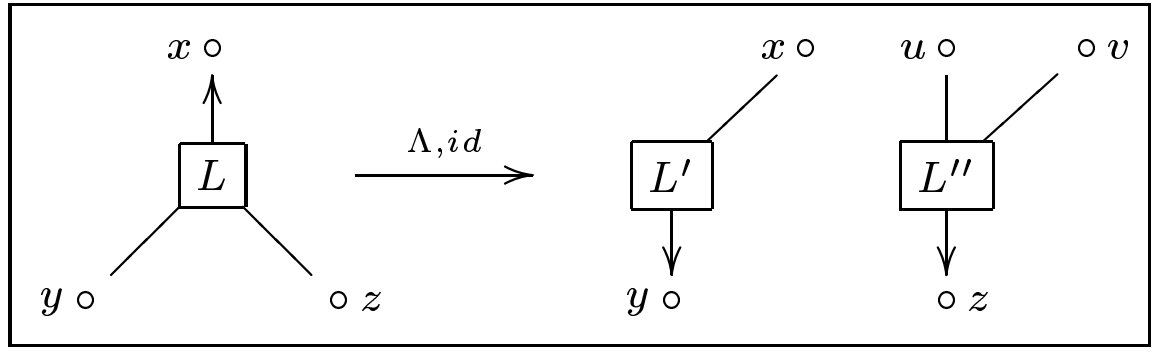

Graphs: Semantics (1)

$$(par)\ \frac{\Gamma \vdash G_1 \xrightarrow{\Lambda,\pi} \phi \vdash G_2 \qquad \Gamma' \vdash G_1' \xrightarrow{\Lambda',\pi'} \phi' \vdash G_2'}{\Gamma, \Gamma' \vdash G_1 | G_1' \xrightarrow{\Lambda \cup \Lambda', \pi \cup \pi'} \phi, \phi' \vdash G_2 | G_2'} \qquad \Gamma \cap \Gamma' = \emptyset$$

$$(res)\ \frac{\Gamma, x \vdash G_1 \xrightarrow{\Lambda,\pi} \phi \vdash G_2}{\Gamma \vdash \nu\ x.G_1 \xrightarrow{\Lambda', \pi|_\Gamma} \phi' \vdash \nu\ \vec{z}.G_2}$$

$$\begin{cases} (\pi(x) = \pi(y) \wedge x \neq y) \Rightarrow \pi(x) \neq x \\ \Lambda(x) \uparrow \text{ or } \Lambda(x) = (\tau, \langle\rangle), \\ \Lambda' = \Lambda - (x, \tau, \langle\rangle) \\ \vec{z} = \phi - \phi' \end{cases}$$

Graphs: Semantics (2)

$$(merge1)\ \frac{\Gamma, x, y \vdash G_1 \xrightarrow{\Lambda,\pi} \phi \vdash G_2}{\Gamma, x \vdash \sigma G_1 \xrightarrow{\Lambda', \pi;\rho|_{\Gamma,x}} \phi' \vdash \nu\,\vec{u}.\rho G_2}$$

$$\begin{cases} \Lambda(y) \uparrow \\ \sigma = (y \mapsto x) \\ \rho = (\pi(y) \mapsto \pi(x)) \\ \Lambda' = \lambda z.\rho(\Lambda(z)) \\ \vec{u} = \rho(\sigma(\phi)) - \phi' \end{cases}$$

$$(merge2)\ \frac{\Gamma, x, y \vdash G_1 \xrightarrow{\Lambda \cup \{(x,a,\vec{v}),(y,\overline{a},\vec{w})\},\pi} \phi \vdash G_2}{\Gamma, x \vdash \sigma G_1 \xrightarrow{\Lambda' \cup \{(x,\tau,\langle\rangle)\},\pi;\rho|_{\Gamma,x}} \phi' \vdash \nu\,\vec{u}.\rho G_2}$$

$$\begin{cases} \sigma = (y \mapsto x) \\ \rho = mgu(\sigma(\vec{v}) \mapsto \sigma(\vec{w})) \\ \Lambda' = \lambda z.\rho(\Lambda(z)) \\ \vec{u} = \rho(\sigma(\phi)) - \phi' \end{cases}$$

An Example:
Graphs for klaim and routing

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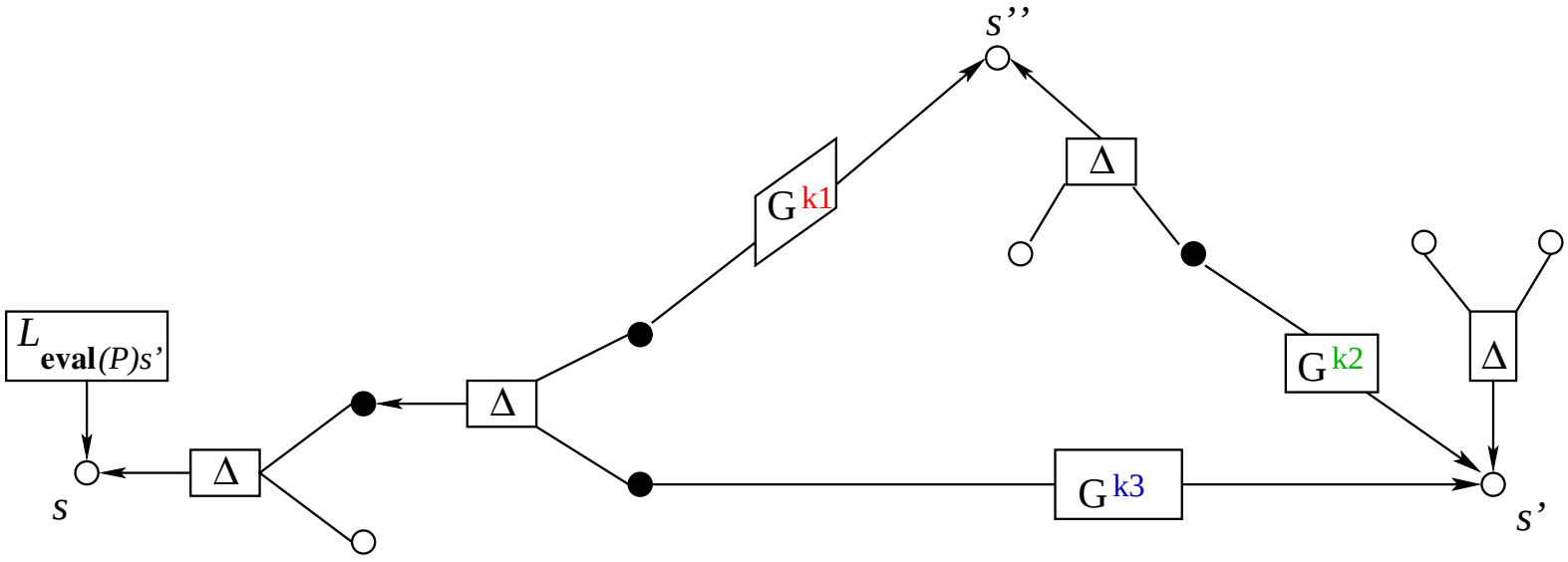

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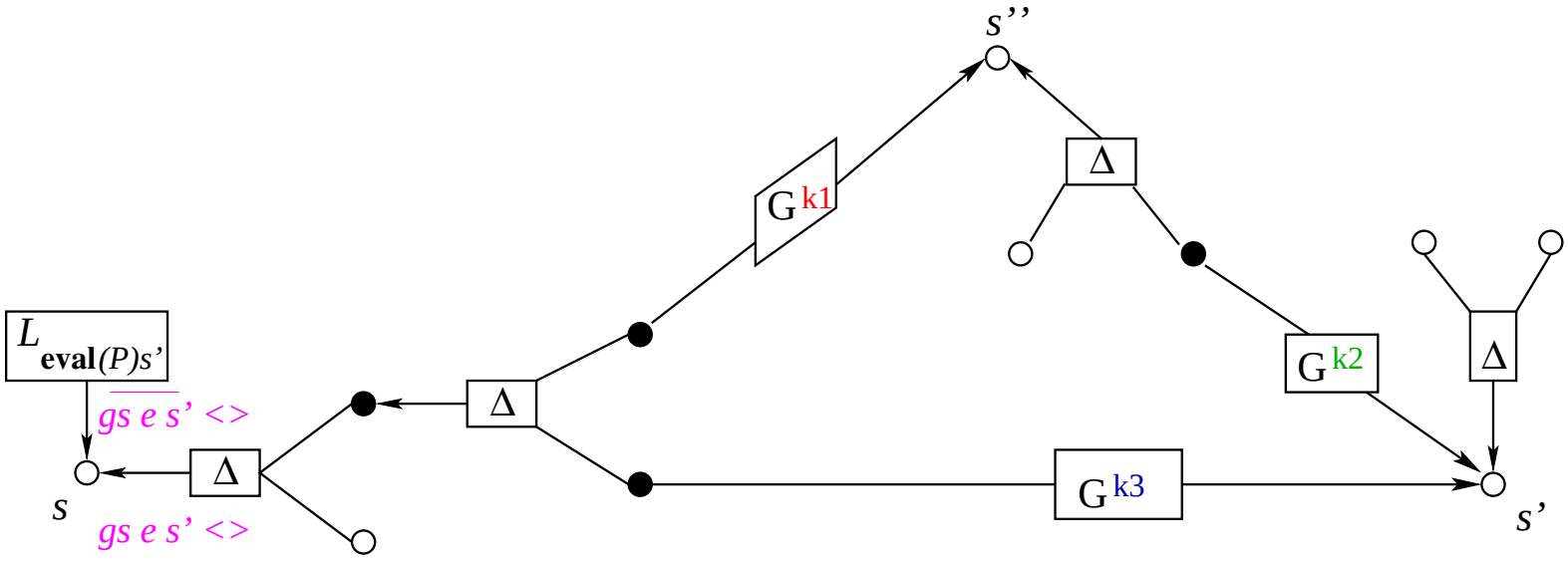

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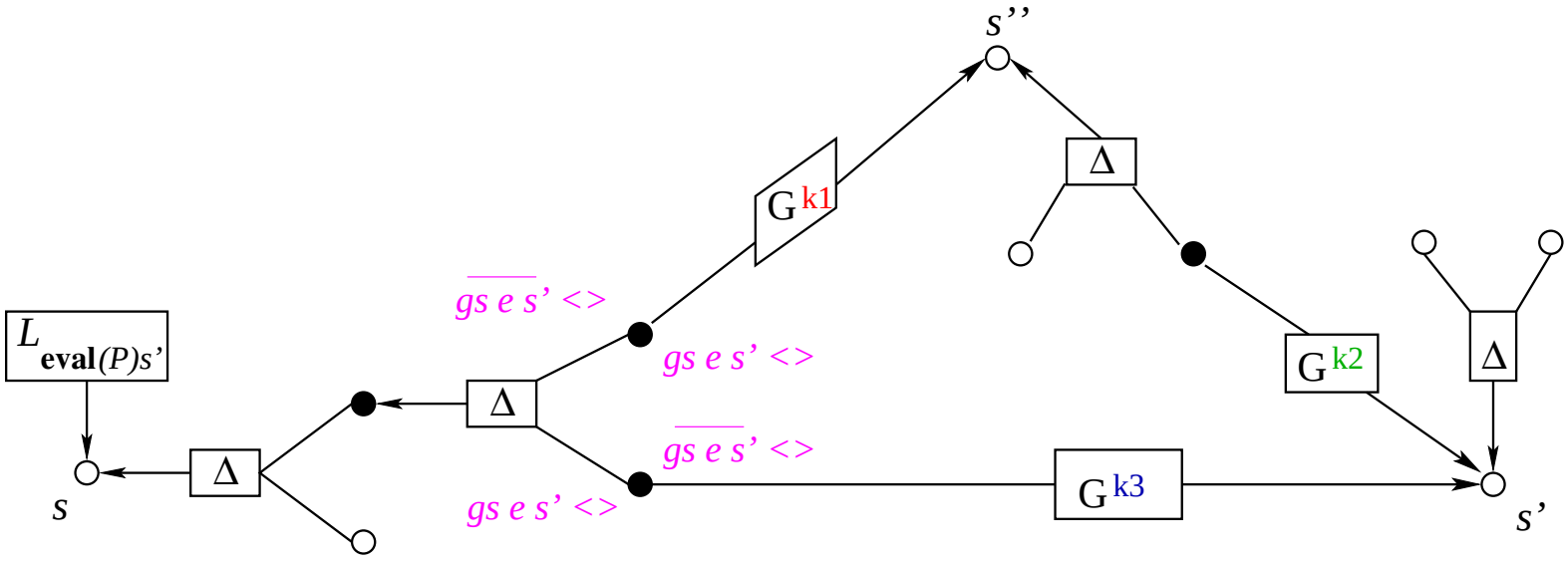
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G k1
Δ
$\overline{gs\ e\ s'\ <>}$
$L_{\mathbf{eval}(P)s'}$
gs e s' <>
G k2
Δ
Δ
Δ
$\overline{gs\ e\ s'\ <>}$
s
gs e s' <>
G k3
s'

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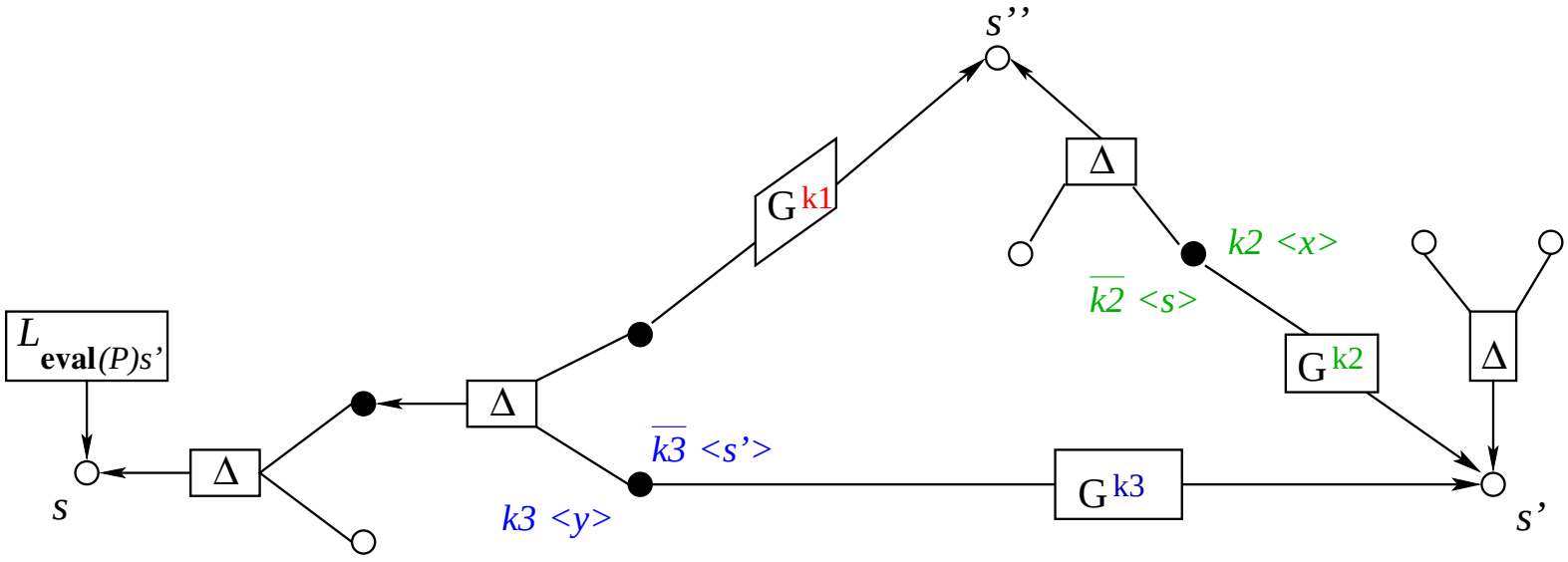

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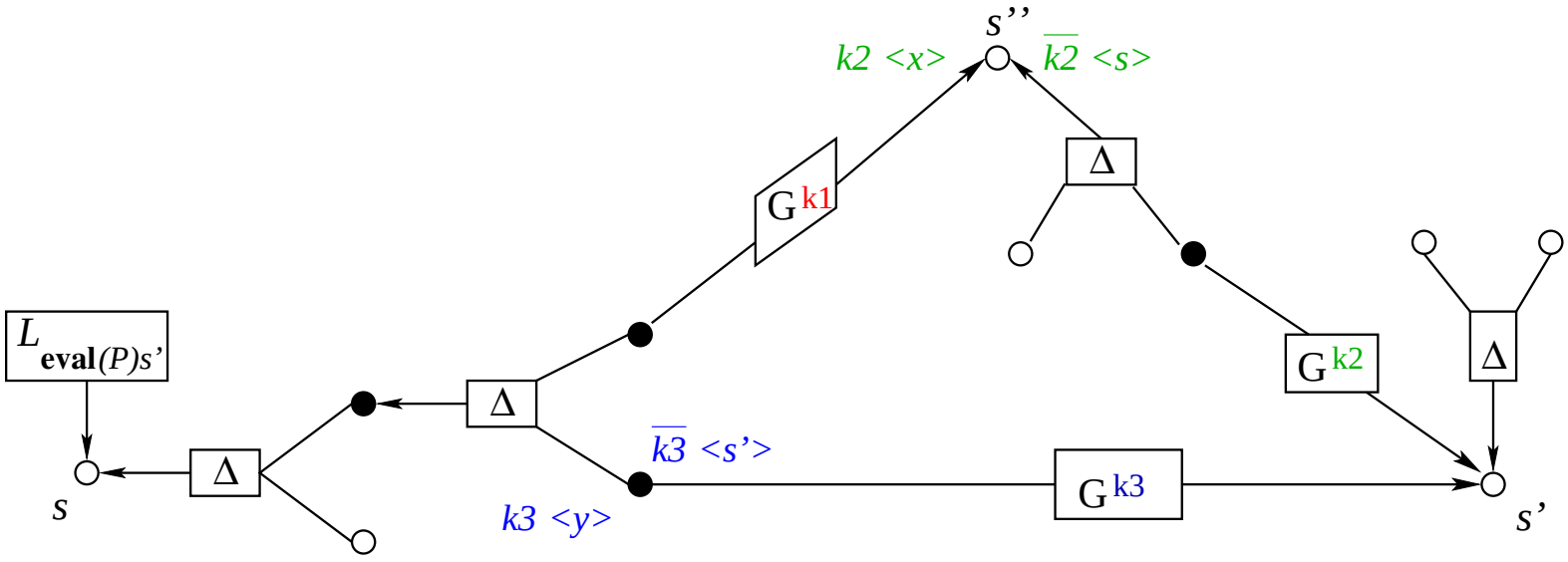

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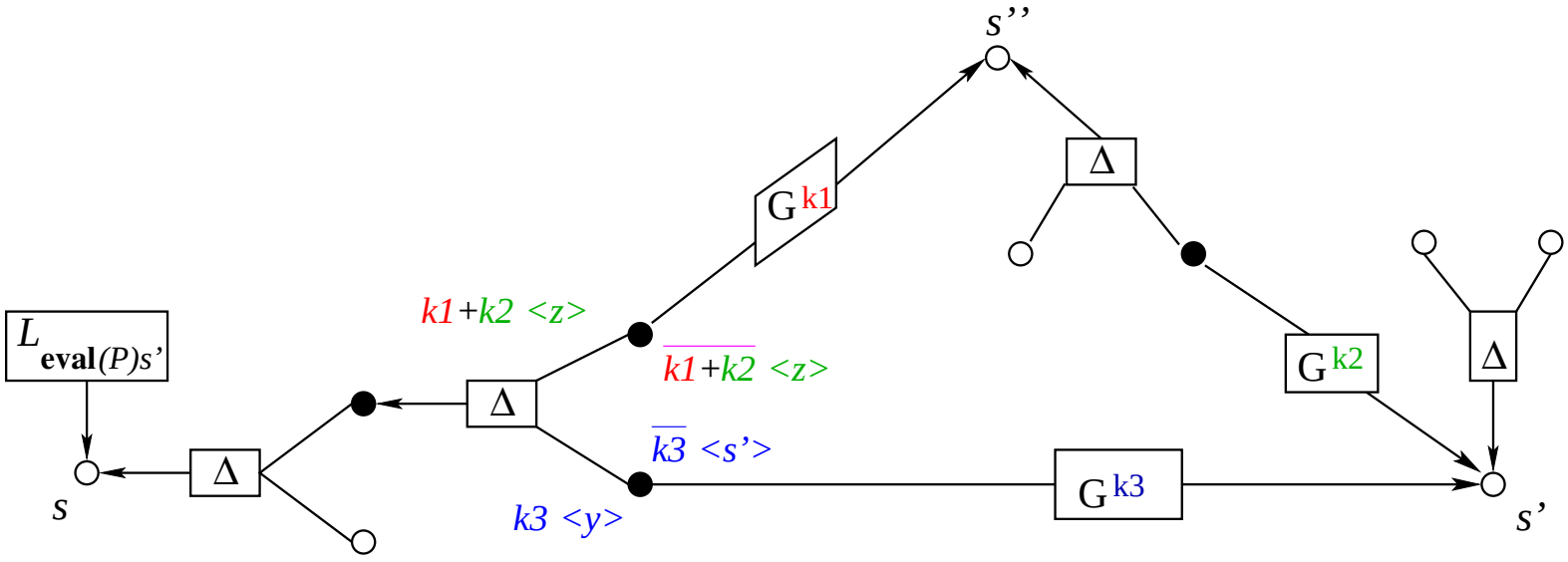

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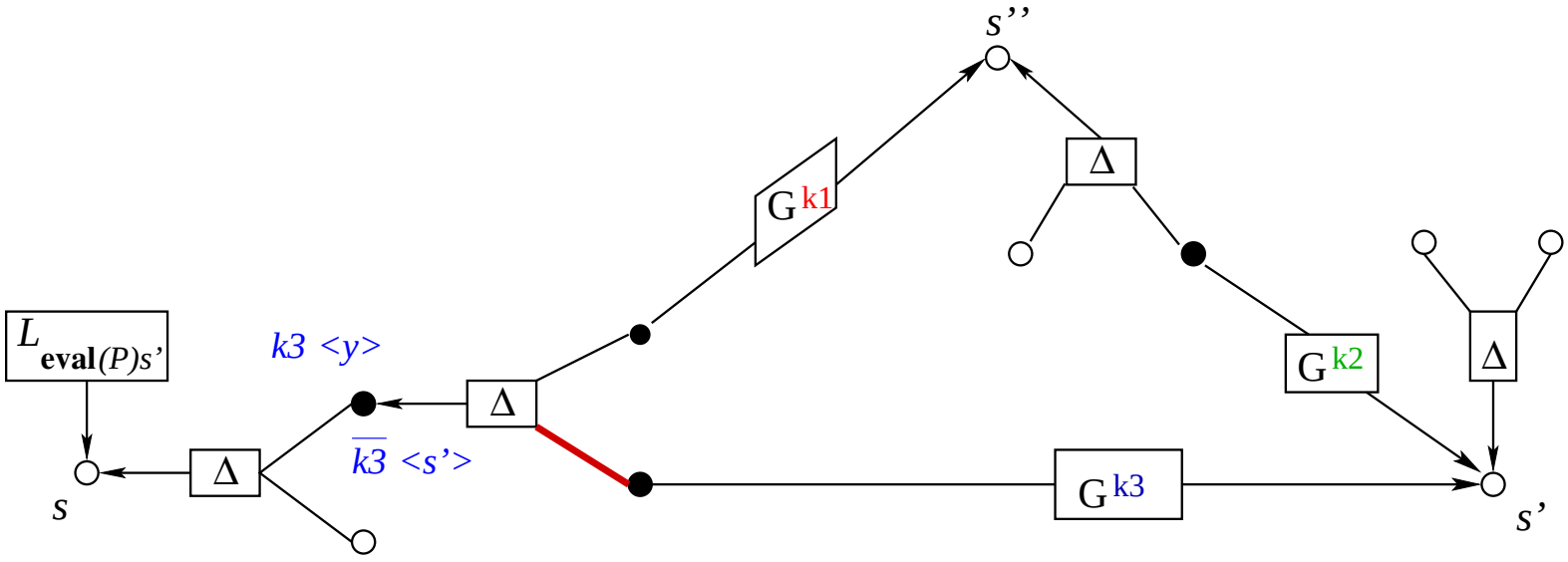

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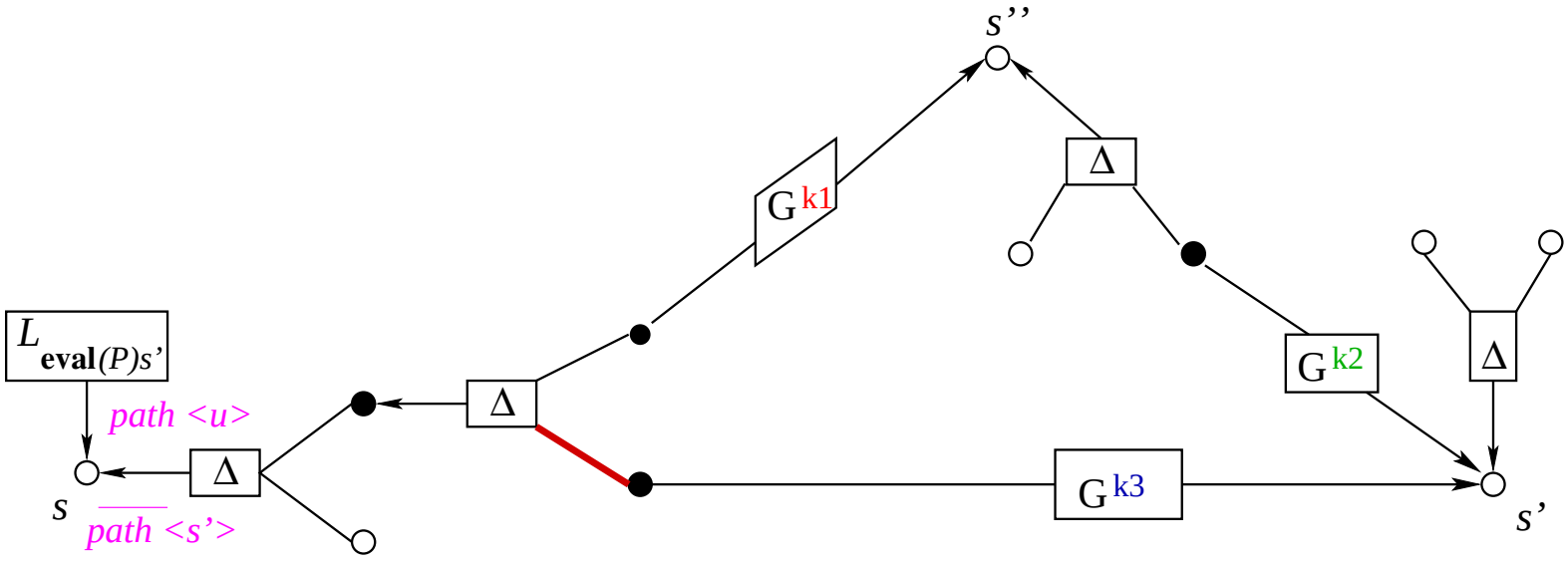

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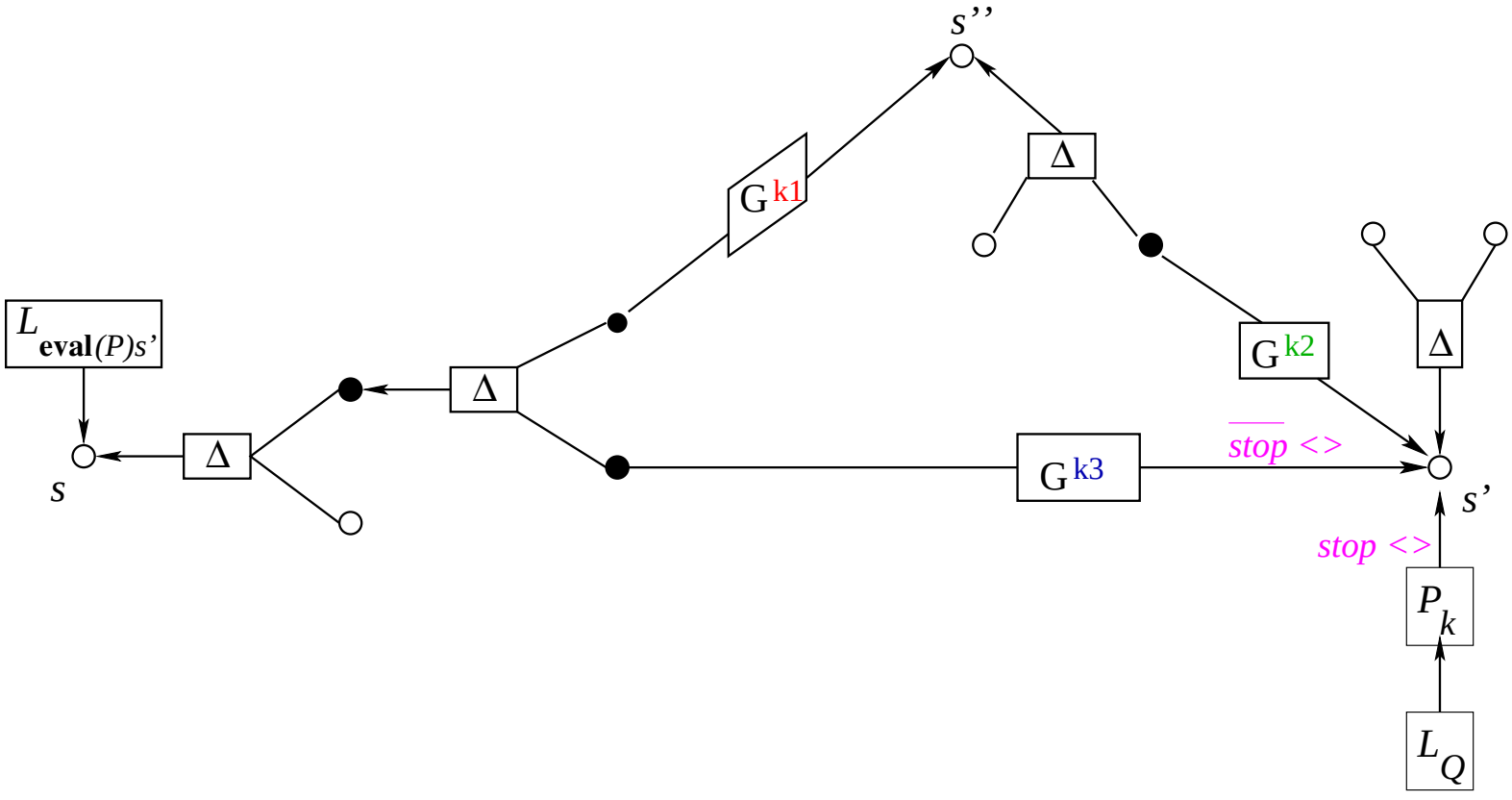

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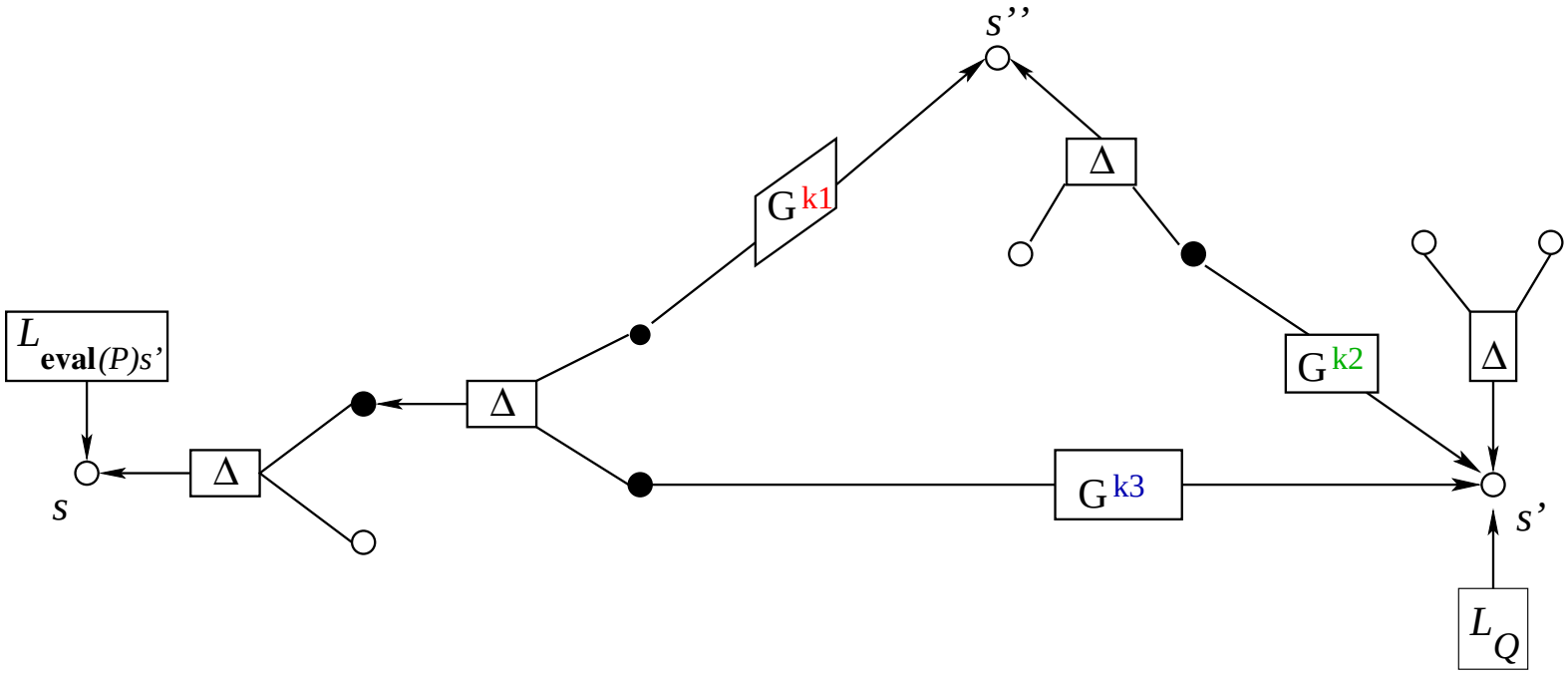

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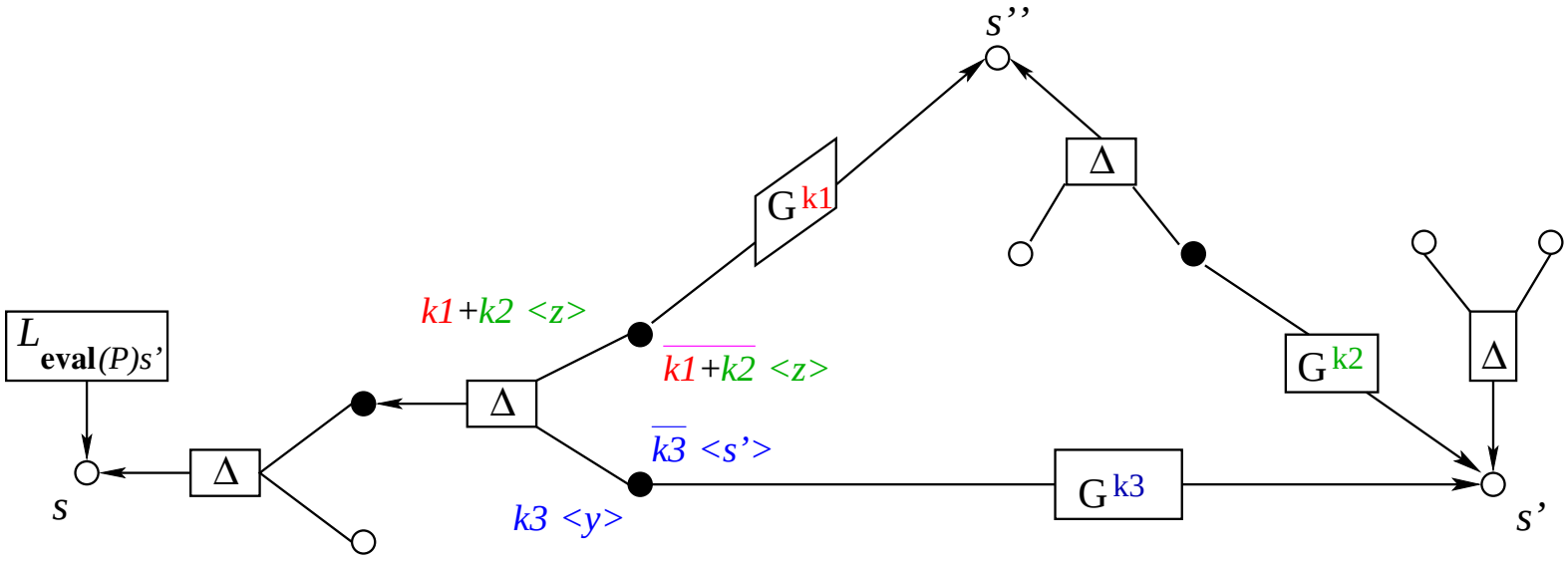

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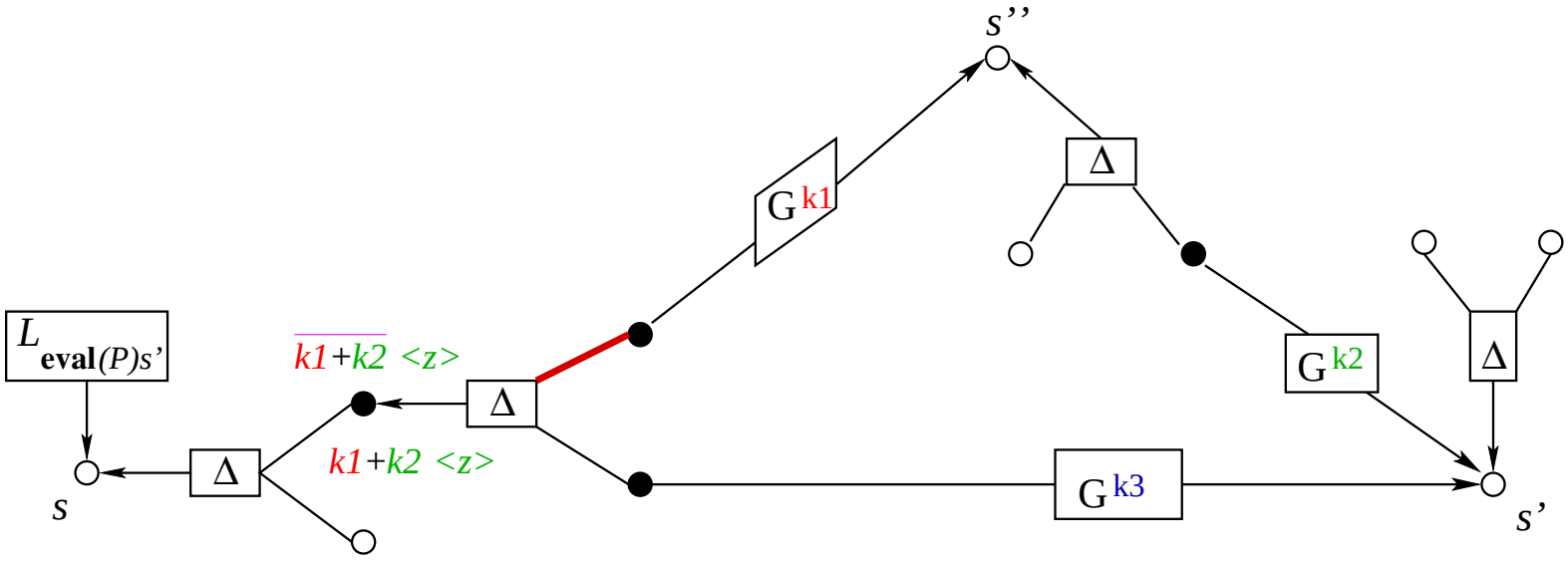

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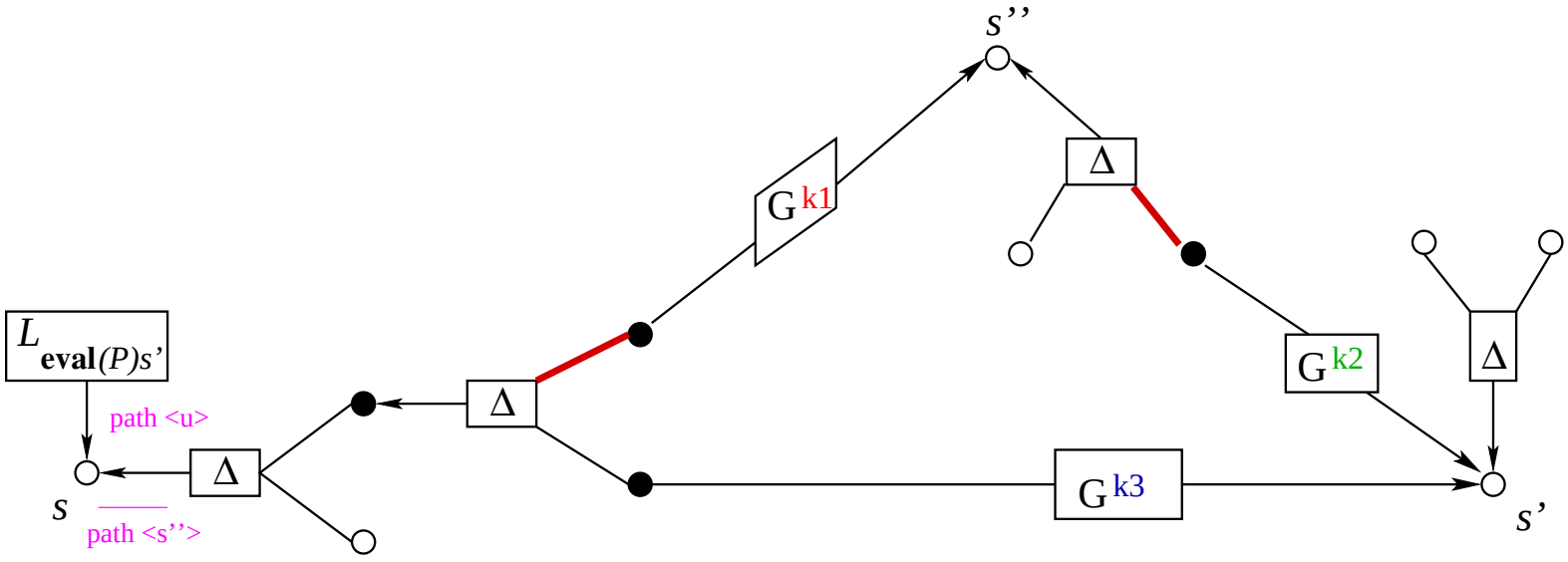

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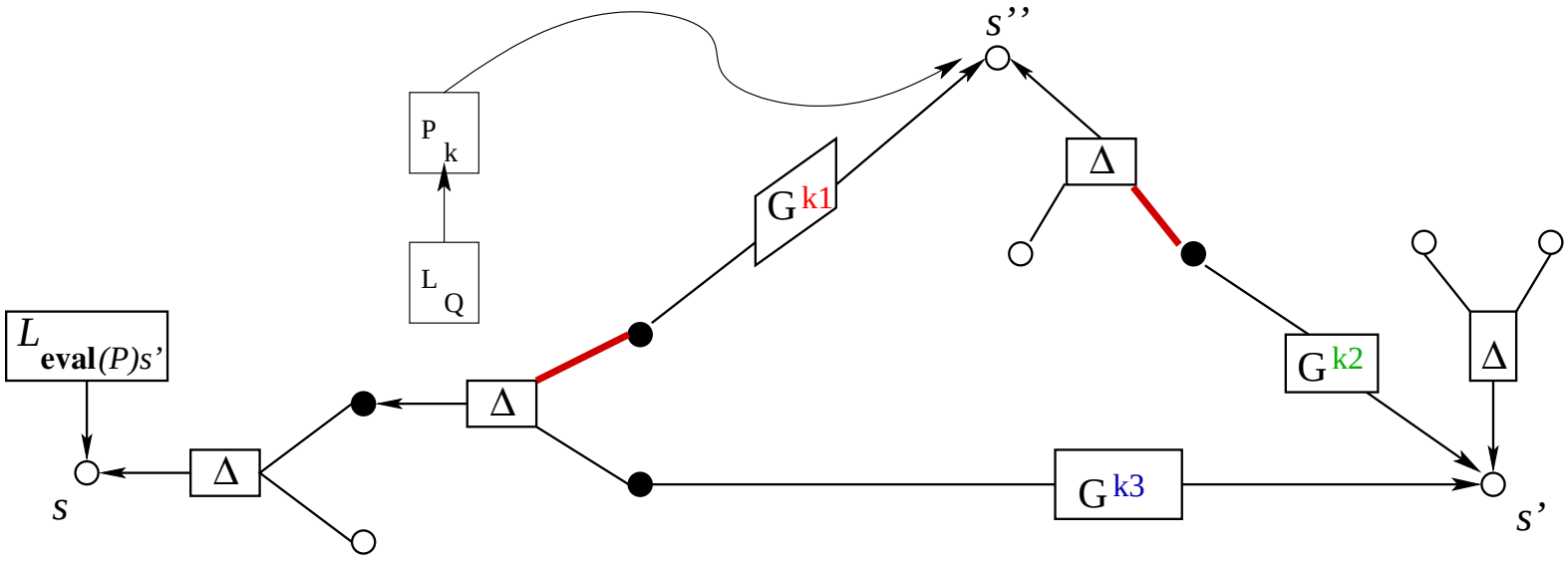

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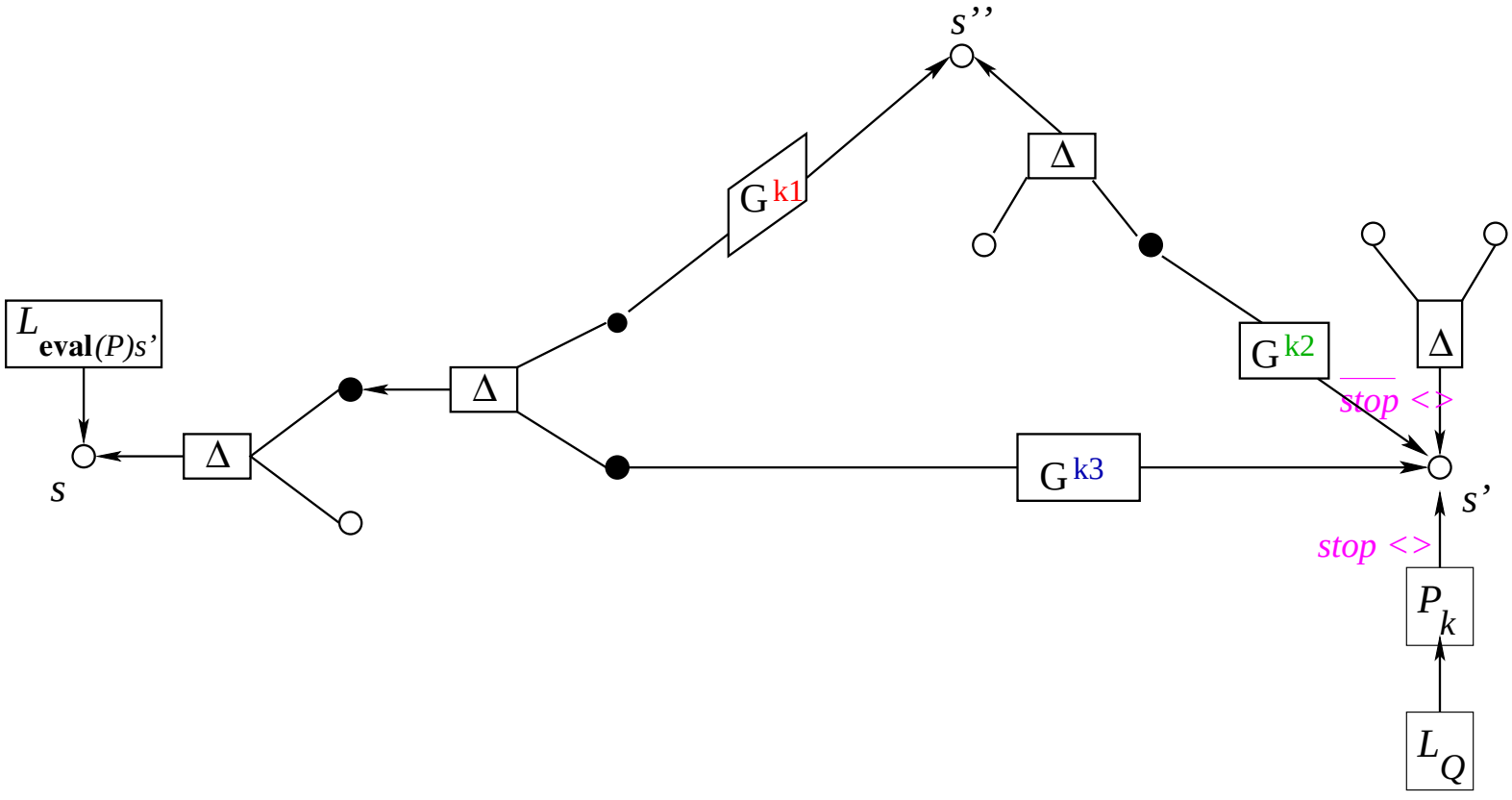
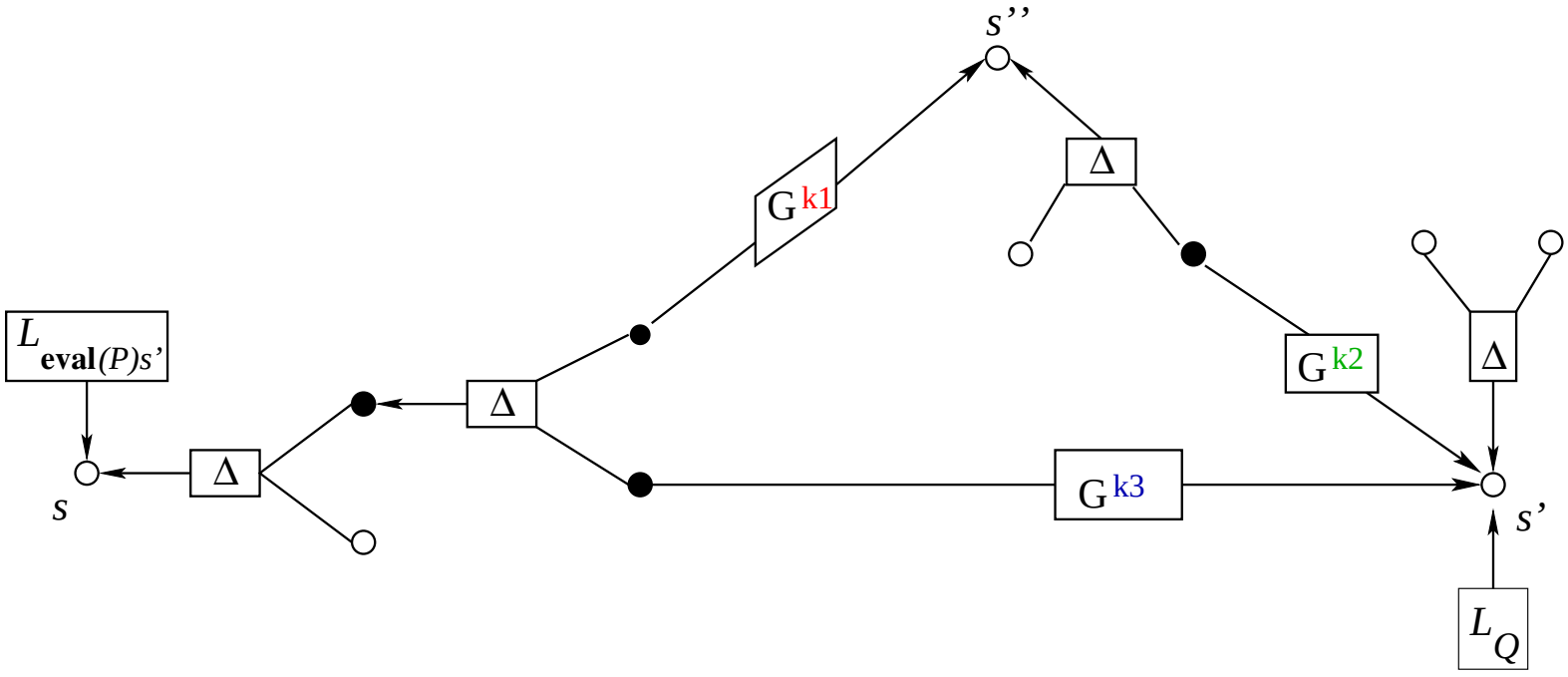
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