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Adding Weights to Dynamic Pushdown Networks

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Motivation

- Weighted Pushdown Systems [RSJM05]
  - Extend Pushdown Systems with Weights
  - Generalize interprocedural Dataflow Analysis
- Dynamic Pushdown Networks [BMOT05]
  - Model Network of parallel Processes
  - Dynamic Creation of Processes
- Weighted Dynamic Pushdown Networks
  - Combination of WPDS and DPN
  - Generalize interprocedural Dataflow Analysis of parallel Processes with dynamic Process Creation

Weighted Dynamic Pushdown System

- WDPN $\mathcal{W} = (\mathcal{M}, \mathcal{S}, f)$
  - DPN $\mathcal{M} = (P, \Gamma, \Delta)$
    - Configurations $(P\Gamma^*)^*$
    - Transition Rules $p\gamma \hookrightarrow c$, $c \in (P\Gamma^*)^* P\Gamma^*$
  - Semiring $\mathcal{S} = (D, \oplus, \odot, 0, 1)$
  - Weight Function $f : \Delta \to D$
- Interleaving Semantics
- Abstraction $\alpha(r_1 \ldots r_n) = f(r_1) \odot \cdots \odot f(r_n)$

Generalised Pushdown Predecessor Problem

$$\delta(C_1, C_2) = \alpha(\text{Paths}(C_1, C_2))$$

Executions of a DPN

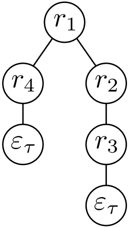
$$C_1 = \{p\gamma_1\gamma_2\}$$
$$C_2 = \{p\gamma_6 p\gamma_5\}$$

$$r_1 = p\gamma_1 \hookrightarrow p\gamma_3 p\gamma_4 \quad \text{ID}$$
$$r_2 = p\gamma_4 \hookrightarrow p \quad \text{ID}$$
$$r_3 = p\gamma_2 \hookrightarrow p\gamma_5 \quad \text{KILL}$$
$$r_4 = p\gamma_3 \hookrightarrow p\gamma_6 \quad \text{GEN}$$

$$p\gamma_1\gamma_2 \longrightarrow p\gamma_3 p\gamma_4\gamma_2 \longrightarrow^* p\gamma_6 p\gamma_5$$

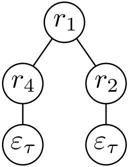
$$\{r_1 r_4 r_2 r_3, \quad (\text{ID} \odot \text{GEN} \odot \text{ID} \odot \text{KILL}) \oplus$$
$$r_1 r_2 r_4 r_3, \quad (\text{ID} \odot \text{ID} \odot \text{GEN} \odot \text{KILL}) \oplus$$
$$r_1 r_2 r_3 r_4\} \quad (\text{ID} \odot \text{ID} \odot \text{KILL} \odot \text{GEN}) = \text{GEN}$$

Execution Hedges of a DPN



=

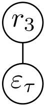
$p\gamma \Longrightarrow cp'$



$(\mathsf{ID} \odot \mathsf{GEN} \odot \mathsf{ID}) \oplus$
$(\mathsf{ID} \odot \mathsf{ID} \odot \mathsf{GEN}) = \mathsf{GEN}$

;

$p\gamma \Longrightarrow cp'w$



KILL

$\mathsf{GEN} \odot \mathsf{KILL} = \mathsf{KILL}$

Reaching Paths and Hedges

$$\mathsf{Paths}(C_1, C_2) = \psi(\mathsf{Hedges}(C_1, C_2))$$

Branching Weighted Dynamic Pushdown System

- BWDPN $\mathcal{B} = (\mathcal{M}, \mathcal{E}, \bar{f})$
  - DPN $\mathcal{M} = (P, \Gamma, \Delta)$
  - Extended Semiring $\mathcal{E} = (E, \bar{\oplus}, \bar{\odot}, \bar{\otimes}, \bar{0}, \bar{1})$
    - $(e_1 \bar{\otimes} e_2) \bar{\odot} e_3 = e_1 \bar{\otimes}(e_2 \bar{\odot} e_3)$
  - Weight Function $\bar{f} : \Delta \to E$
- Branching Semantics
- Abstraction $\beta(r(\tau_1 \dots \tau_n)) = \bar{f}(r) \bar{\odot}(\beta(\tau_1) \bar{\otimes} \dots \bar{\otimes} \beta(\tau_n))$

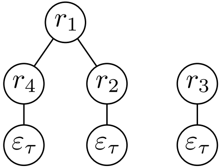
Branching Generalised Pushdown Predecessor Problem

$$\theta(C_1, C_2) = \beta(\text{Hedges}(C_1, C_2))$$

Connection

- Extension $(\mathcal{S}, \mathcal{E}, \iota, \eta)$
  - Embedding $\iota : D \to E$
  - Projection $\eta : E \to D$

$(\mathrm{ID} \,\bar{\odot}\, (\mathrm{GEN} \,\bar{\otimes}\, \mathrm{ID})) = \underline{\mathrm{GEN}}$



KILL

$\underline{\mathrm{GEN}} \,\bar{\odot}\, \mathrm{KILL} = \underline{\mathrm{GEN}} \qquad \eta(\underline{\mathrm{GEN}}) = \mathrm{GEN}$

Connection

$$\delta(C_1, C_2) = \eta(\theta(C_1, C_2)) \text{ für } \bar{f}(r) = \iota(f(r))$$

Applications/Future Work

- Applications
  - Shortest Path
  - Bitvector Analyses
  - KILL/GEN Analyses
- Future Work
  - Iterate Method
    - Synchronisation
  - Additional Weight Domains
    - Generalize Construction
    - Weights for Hedges

Bibliography

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