Unlocking Blocked Communicating Processes

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(Dead)locks and (Dead)lock-Free

$$\mathrm{in}(a, P) \stackrel{\text{def}}{=} P \equiv P' \parallel a.P'' \qquad \mathrm{out}(a, P) \stackrel{\text{def}}{=} P \equiv P' \parallel \bar{a}.P''$$

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$$\mathrm{lock}(P) \stackrel{\text{def}}{=} \mathrm{wait}(a,P) \quad \text{and} \quad \forall Q.\ P \longrightarrow^* Q \text{ implies } \neg\mathrm{sync}(a,Q)$$

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Deadlocks and Locks

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1. **0** and Ω (dead) lock-free

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6. $a.\bar{b}.\mathbf{0} \parallel b.\bar{a}.\mathbf{0}$ deadlocked
7. $a.(\bar{b}.\mathbf{0} \| c.\mathbf{0}) \parallel b.\bar{a}.\mathbf{0} \parallel \bar{c}.\mathbf{0}$ deadlocked

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$$a.\bar{a}.\mathbf{0} \parallel \underbrace{\bar{a}.a.\mathbf{0}}_{\text{catalyser code}}$$

Issues with resolving (dead)locks through Catalysers

Value-passing:

$$a(x).\,\text{if } \mathit{condition}(x) \text{ then } P \text{ else } Q$$

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Linearity:

$$a.\bar{a}.\mathbf{0} \parallel \bar{a}.a.\mathbf{0} \quad \longleftarrow \quad \text{illegal!!}$$

(Dead)lock resolution by Disentangling

Example

Consider the program

$$a(x).\Big(\bar{a}\langle 1\rangle.\text{if } x \geq 1 \text{ then } \bar{b}\langle 4\rangle.\mathbf{0} \text{ else } \bar{b}\langle 2\rangle.\mathbf{0}\Big)$$

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... and refactor the program accordingly

$$\bar{a}\langle 1\rangle.\mathbf{0} \parallel a(x).\Big(\text{if } x \geq 1 \text{ then } \bar{b}\langle 4\rangle.\mathbf{0} \text{ else } \bar{b}\langle 2\rangle.\mathbf{0}\Big)$$

Disentangling Locks

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1. Detection
2. Refactoring

Detection: Identifying the target set

1. Simplify setting: processes using **linear ports only**.
2. Simplify further: **complete** processes.
3. We are left with two sets of processes:
   - The lock-free processes
   - The complete but **not** lock-free.

Detection: Characteristing the target set

Example (Not Lock-free)

- $a.\bar{b}.\mathbf{0} \parallel b.\bar{a}.\mathbf{0}$
- $a.(\bar{b}.\mathbf{0} \| c.\mathbf{0}) \parallel b.\bar{a}.\mathbf{0} \parallel \bar{c}.\mathbf{0}$

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- $d.\left(a.\bar{b}.\mathbf{0} \parallel b.\bar{a}.\mathbf{0}\right) + d.\mathbf{0} \parallel \bar{d}.\mathbf{0}$
- $\bar{d}.\left(a.(\bar{b}.\mathbf{0} \parallel c.\mathbf{0})\right) \parallel d.\left(b.\bar{a}.\mathbf{0} \parallel \bar{c}.\mathbf{0}\right)$

Detection: Characteristing the target set

$$\mathrm{cin}(a,P) \stackrel{\text{def}}{=} P \equiv \mathcal{C}[Q] \text{ and } \mathrm{in}(a,Q)$$

$$\mathrm{cout}(a,P) \stackrel{\text{def}}{=} P \equiv \mathcal{C}[Q] \text{ and } \mathrm{out}(a,Q)$$

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$$\mathrm{sl}(P) \stackrel{\text{def}}{=} \mathrm{dlock}(P) \text{ and } \mathrm{tcmp}(P)$$

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2. Approximation:

Under or Over Approximate?

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Or else disentangle it as: $(\bar{a}.\mathbf{0} \parallel a.\bar{b}.c.\mathbf{0}) \parallel (\bar{c}.\mathbf{0} \parallel b.\mathbf{0})$

Value Passing and Static Binding

Example

$$a(x).\bar{b}\langle x+1\rangle.c(y).\mathbf{0} \;\parallel\; \bar{c}\langle 5\rangle.b(z).\bar{a}\langle 7\rangle.\mathbf{0}$$

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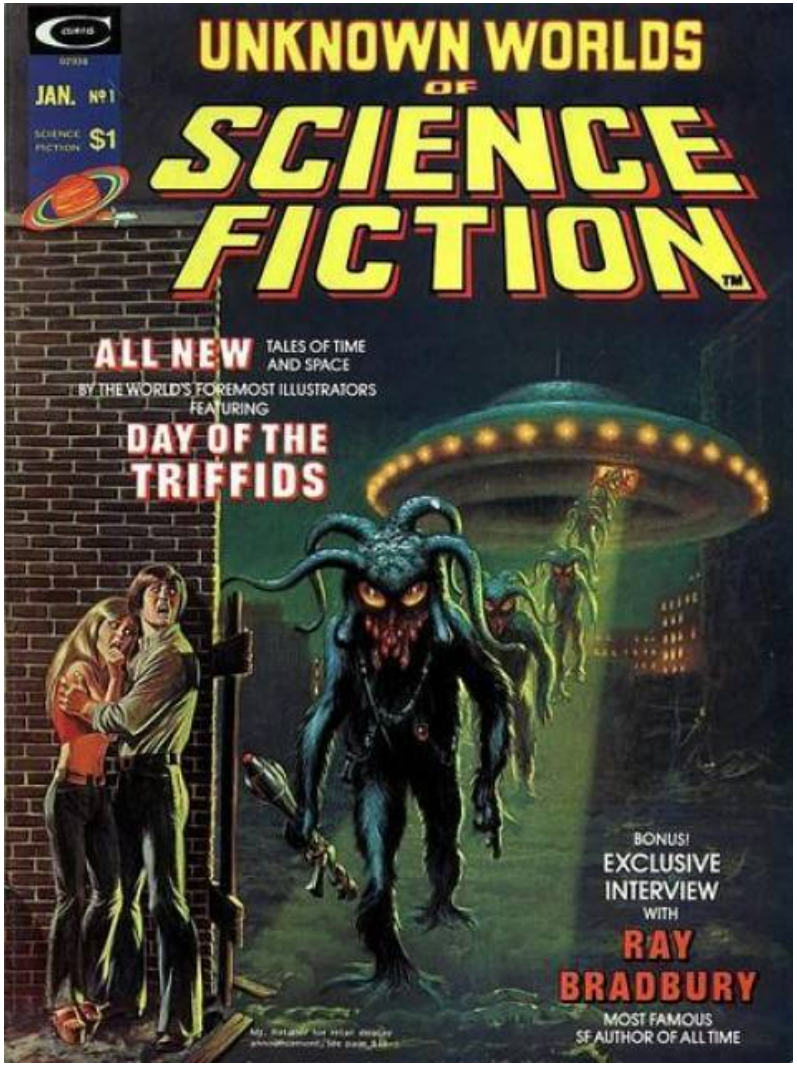
But what about:

$$a(x).\bar{b}\langle x+1\rangle.c(y).\mathbf{0} \;\|\; \bar{c}\langle 5\rangle.b(z).\bar{a}\langle z-1\rangle.\mathbf{0}$$

Channel Passing



Conclusion

- The problem of disentangling seems to be quite different from its dual counterpart, typechecking (dead)lock-free processes.
- We can characterise the dual of lock-free processes as potentially self-locking processes.
- There is a tension when detecting locks between compositionality and appoximation.
- The criteria for adequate refactoring are not obvious and some may be conflicting.