Programming in a stock-flow consistent framework

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A simple SFC-ABM model

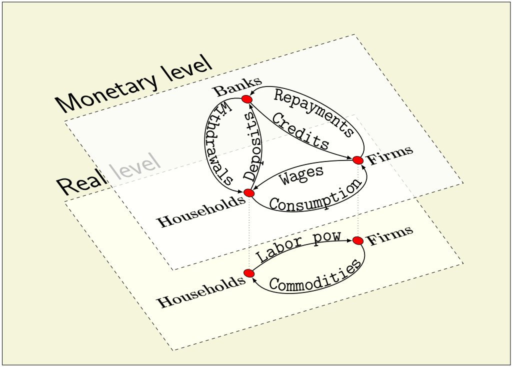

Figure: credit Pascal Seppecher

Concurrent processes in pi-calculus

- Processes (P, P', Q etc.)
  - Processes in parallel $P \mid Q$
  - Null process 0
- Communications

$$\bar{a}(v).P_1 \mid a(x).P_2 \xrightarrow{a} P_1 \mid P_2[x \leftarrow v]$$

Concurrency in pi-calculus

$$\begin{tikzcd}
 & P_1 \mid P_2[x \leftarrow v] \mid a(y).P_3 \\
\bar{a}(v).P_1 \mid a(x).P_2 \mid a(y).P_3 \arrow[ur, "a"] \arrow[dr, "a"'] & \\
 & P_1 \mid a(x).P_2 \mid P_3[y \leftarrow v]
\end{tikzcd}$$

Bisimulation

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A bisimulation is a binary relation $\cong$ such that if $P \cong Q$ then

- $\forall P'$, and $\forall a$ st $P \xrightarrow{a} P'$ $\exists Q'$ st $Q \xrightarrow{a} Q'$ and $P' \cong Q'$
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Two process P and Q are said to be *bisimilar* if there exists a bisimulation $\cong$ such that $P \cong Q$.
We can further say that P and Q always expose the same behaviour if for any context, R, $P \mid R$ is bisimilar to $Q \mid R$.

Choosing the observable facts

Channel names are the observables

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- Do we need agent ids ?
- Do we need money amounts ?

All you can do with money

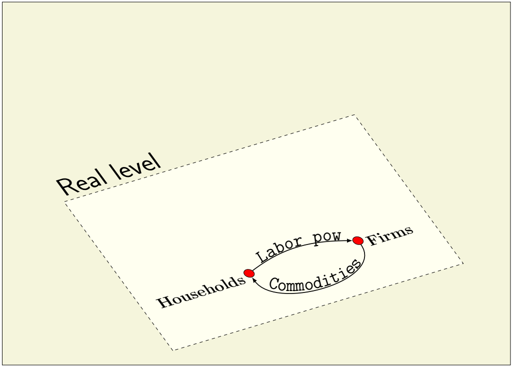

Figure: No observable money flows

Interaction based models

Interaction matrix

	Household	Firm	Bank
Household	. . .	Buy, Work	
Firm	Appoint		
Bank			

In process calculi accounts, transactions, firms, households, Banks will all sit at the same level (all processes).

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Existence ?coinduction.

Function type

If a function f is of type $A \to B$ and its argument v is of type A and if the computation $f(v)$ does not run forever or raise an error then the result is of type B.
A type is an invariant of the computation known from the type system (verification at compile time).
Types are strongly related with logical propositions.

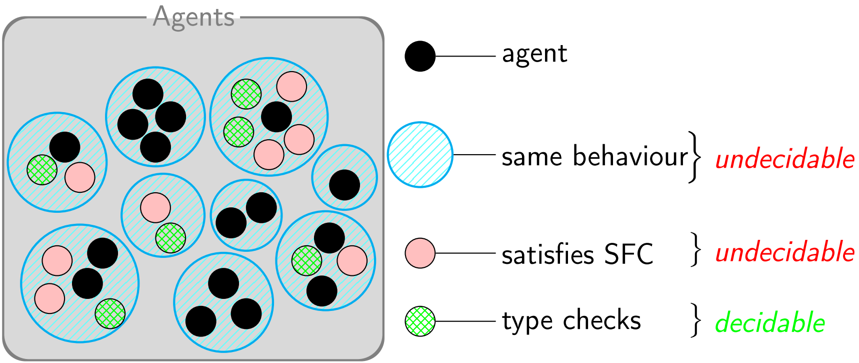
An example of a free theorem

If f is of type $\forall\alpha, \mathsf{List}\,\alpha \rightarrow \mathsf{Int}$ then for any type A, for any data l of type $\mathsf{List}\,A$, and for any $g : A \rightarrow B$:

$$f(l) = f(map(g, l))$$

Where $map(g, l)$ is the list obtained by applying g pointwise to the elements of l.

Extensionnal completeness



Extensionnal completeness

$\forall b,$ $\exists$ 🔴 $\in$ f $\Longleftrightarrow$ $\exists$ 🟩 $\in$ f

Automatically generated behaviours

With a language constrained structurally (induction) we can generate new behaviours automatically.

More data coming

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- Facebook : 4 Pb / year (4×10^{15} bytes)
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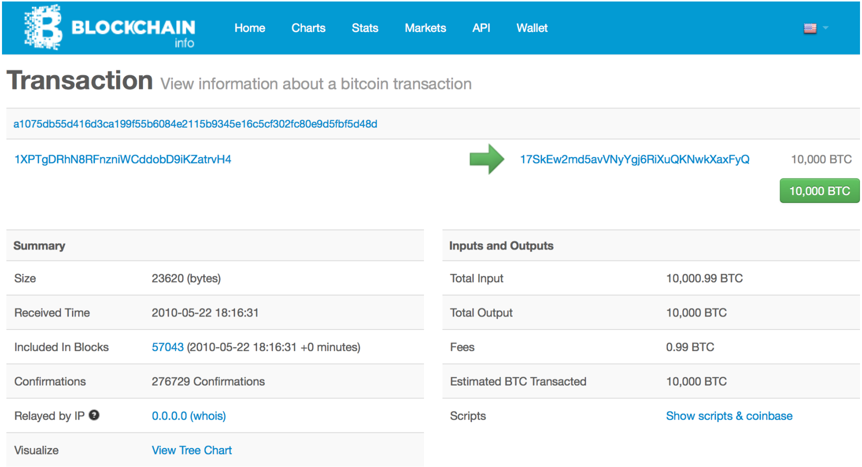
Real data in heterogeneous datasets $\Longrightarrow$ linked data

Tracking money ?



Transaction View information about a bitcoin transaction

a1075db55d416d3ca199f55b6084e2115b9345e16c5cf302fc80e9d5fbf5d48d

1XPTgDRhN8RFnzniWCddobD9iKZatrvH4 → 17SkEw2md5avVNyYgj6RiXuQKNwkXaxFyQ 10,000 BTC

10,000 BTC

Summary	
Size	23620 (bytes)
Received Time	2010-05-22 18:16:31
Included In Blocks	57043 (2010-05-22 18:16:31 +0 minutes)
Confirmations	276729 Confirmations
Relayed by IP ?	0.0.0.0 (whois)
Visualize	View Tree Chart

Inputs and Outputs	
Total Input	10,000.99 BTC
Total Output	10,000 BTC
Fees	0.99 BTC
Estimated BTC Transacted	10,000 BTC
Scripts	Show scripts & coinbase