Combining Timing, Localities and Migration in a Process Calculus

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BCTCS - 05/04/2006

Outline

Aim

- Combine discrete time and mobility to gain a calculus with:
  - **Global synchronization**
  - **Localities**
  - **Migration**
- Two routes: we take that of adding mobility to a calculus with global synchronization.
- Be as *conservative* as possible.

Motivation

- Masters project developed semantics for the Cashew-S web-service orchestration language [Norton, Foster and Hughes, 2005]
- Used the *Calculus for Synchrony and Encapsulation* (**CaSE**) [Norton, Lüttgen and Mendler, 2005], a conservative extension of CCS
- **Idea**: Would be interesting to extend CaSE with mobility

Hennessy's Temporal Process Language (TPL)

- CCS with the addition of a single clock.
- Time, but not as we naively know it.
- Primary motivation is **synchronization**
- Exhibits a phenomenon known as **maximal progress**
- The clock ticks after all τ actions.

Timeouts

Example

$$\lfloor E \rfloor \sigma (F)$$

- E and F are processes and σ is a clock.
- F acts if E times out on the clock σ

Scaling Synchronization

Example

$$a.0 \mid \overline{a}.0$$

- Easy to do *local synchronization* in CCS – one sender, one receiver.
- But what about with an arbitrary number (n) of processes?
- Can be done, but *not compositionally*

The Problem

Example

$$\overline{a}_1.\overline{a}_2.E \mid a_1.F \mid a_2.G$$

- We can model the case with two receivers fine...

The Problem

Example

$\overline{a}_1.\overline{a}_2.\overline{a}_3.E \mid a_1.F \mid a_2.G \mid a_3.H$

- But further composition requires rebuilding the semantics

The Solution

Example

$\mu X.\lfloor\overline{o}.X\rfloor\sigma(P) \mid o.E \mid o.F \mid o.G$

- Recursive output with the clock signal effectively the base case.
- Clock will tick when no more synchronizations can occur.

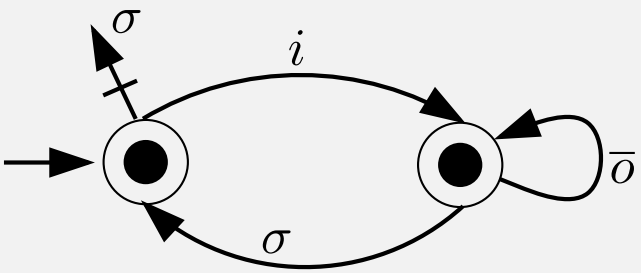
Hierarchies

- Multiple clocks
- Arranged in hierarchies
- Accomplished via *clock hiding*

Example

$((E|F)/\sigma)|G$

Broadcast



- $\mu X.i.(\mu Y.\lfloor\overline{o}.Y\rfloor\sigma(X)) + \Delta$
- Insistence is provided by the *timelock* operator, Δ

What are Localities?

- Localities *group* a set of composed processes.
- Multitude of uses – common one is *distribution*
- Nested localities echo *clock hiding*
- We combine the two.

A Slight Syntax Change

Example

$$((E|F)/\sigma)|G$$

Example

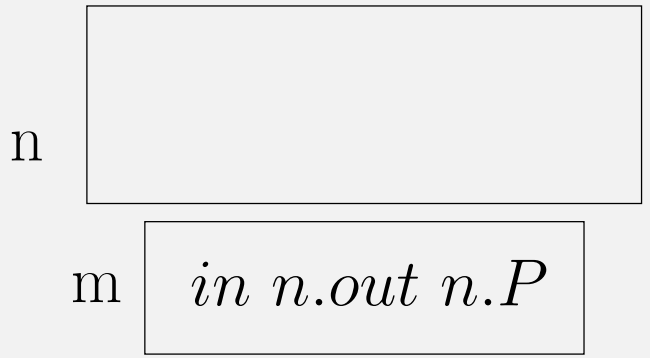
$$(I[E|F]_{\{\sigma\}})|G$$

- Consider
  - *uniqueness* of locality names
  - *structure* – one top-level locality or more?

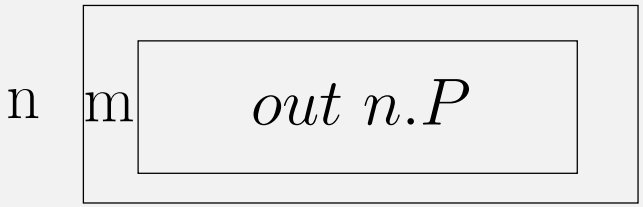
Merging in Ideas from Ambient-based Calculi

- We allow our localities to be moved.
- Adopt ambient-like capabilities:
  - *in n*
  - *out n*
- Expand on this to increase granularity

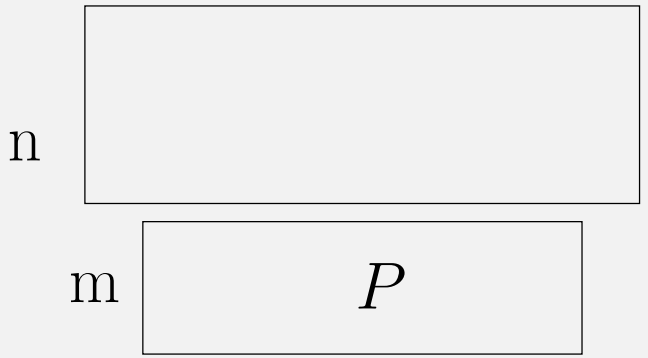
An Example



An Example



An Example



Communication Between Ambients

- Two choices:
  1. *open n* – dissolve *n* from the parent
  2. or add the following Seal calculus primitives, as does Boxed Ambients [Bugliesli, Castagna and Crafa, 2001]:
     - a^n (to child *n*)
     - $a^\uparrow$ (to parent)
     - Or generalize to just a^n, where *n* is an arbitrary locality
- Depends on the use of the model

Using the New Calculus

- Lots of uses we can think of. . .
- Because lots of complex systems with *componentisation* and *dynamic elements*
- Hopefully feed some of this back into the Cashew project
- Useful test base

Our Case Study: Biology

- Lots of cases of moving elements with internal synchronization
- Ambients already used in this context
- P-systems similar and imply a clock
- Interesting area to look into

Further Points

- Mobility via value passing
- Give clocks a value for broadcast
- Typing of processes (given names, processes, clocks and localities)

Conclusions

- Started with CaSE
- Added localities and migration
- Applications specifically web service composition and biology
- Lots of possibilities to take it even further. . .

The End

Thanks for listening.


NORTON, B., FOSTER, S., AND HUGHES, A.
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In *Proceedings of the 2nd International Workshop on Web Services and Formal Methods (WS-FM 2005)* (September 2005), no. 3670 in LNCS, Springer-Verlag, pp. 303–317.


NORTON, B., LÜTTGEN, G., AND MENDLER, M.
A compositional semantic theory for synchronous component-based design.
In *Proceedings of the 14th International Conference on Concurreny Theory (CONCUR '03)* (2003), no. 2761 in LNCS, Springer-Verlag.


BUGLIESLI, M., CASTAGNA, G., AND CRAFA, S.
Boxed ambients.
In *(TACS '01)* (2001), vol. 2215 of *LNCS*, pp. 38–63.