Decidability Problems for Actor Systems

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Actors?

Yes Actors, like in

- Erlang
- Scala
- Rebeca

and like in HATS

HATS stands for

> *Highly Adaptable and Trustworthy Software using Formal Models*

an Integrated Project supported by the 7th Framework Programme of the EC within the FET (Future and Emerging Technologies) scheme.
Main objective:

> *Executable modeling language based on concurrent objects*

See http://www.hats-project.eu/

A Nominal Actor-based Language

Expressions

$$E ::= f \mid x \mid new\ C(\bar{E})$$

Processes

$$\begin{array}{rcl} P & ::= & f := E \cdot P \\ & \mid & x!m(\bar{E}) \cdot P \\ & \mid & let\ x = E\ in\ P \\ & \mid & if\ E = E\ then\ P\ else\ P\ fi \\ & \mid & P + P \end{array}$$

Class definitions

$$C = (m_1(\bar{x}_1) = P_1, \ldots, m_n(\bar{x}_n) = P_n)$$

Programs

$$P \mid C_1, \ldots, C_n$$

Semantics

Configuration = set of Actor states ($Process$, $QueueofMessages$)
Message = $m(\bar{V})$
Asynchronous communication like in *communicating finite state machines* (Turing complete).

Unbounded in

- number of Actors
- size of queues
- number of (local) variables

But no explicit input

Main Decidability Result

Finite number of actors with no field updates

Proof idea

well-structured transitions systems

WSTS

quasi-ordering reflective and transitive relation

well-quasi-ordering quasi-ordering $(X, \leq)$
such that, for every infinite sequence $x_1, x_2, x_3, \cdots,$
there exist $i < j$ with $x_i \leq x_j$.

WSTS $(\mathcal{S}, \rightarrow, \preceq)$
where $\preceq$ is a well-quasi-ordering relation on S such that
$\preceq$ is *upward compatible* with $\rightarrow$:
for every $s_1 \preceq s_1'$ such that $s_1 \rightarrow s_2$, there exists $s_1' \rightarrow^* s_2'$ such that $s_2 \preceq s_2'$.

Ordering Configurations of Actors

- Processes identified up to renaming
- Queues ordered by subsequence relation up to renaming:

$$m_1(\bar{E}_1)\ldots m_k(\bar{E}_k) \leq n_1(\bar{U}_1)\ldots n_h(\bar{U}_h)$$

if

$$\exists i_1 < i_2 < \cdots < i_k \leq h \forall j \in 1..k.\ m_j = n_{i_j} \wedge \bar{E}_j \simeq \bar{U}_{i_j}$$

But also ...

Unbounded stateless actors (no fields) are decidable.

Proof idea

Termination preserving abstraction from actors identities.

Turing Completeness

- Finite number of actors with field updates
- Infinite number of actors without field updates

Proof idea:

simulation of register machines

Future Work

- Futures!
  (Termination detection for active objects.
  Frank S. de Boer, Immo Grabe, Martin Steffen.
  J. Log. Algebr. Program, 2012)
- Release points (coopreative scheduling)