DN2-V2

Notiztitel 15.03.2005

VI Putting things together

Modest is rooted in Process Algebra

A] Modest Syntax

P :: stop | break | act | when (b) P | urgent (b) P |

P ; P | alt {:: P ... :: P} | do {:: P ... :: P} | par {:: P ... :: P}

act palt {:w: P ... :w: P} |

relabel {I} by {G} P | extend {H} P

"Action" "guard" "deadline" "sequencing" "choice" "loop"

assgn assgn

$\in$ Bexp

$\in$ Act

$\in \mathbb{R}^+$

$\subseteq$ Act (lists)

Intermezzo: The structure so far

I Process Algebra

II Markov Algebra and Markov Model Checking

III Timed Automata

IV Cost Models

V Simulation

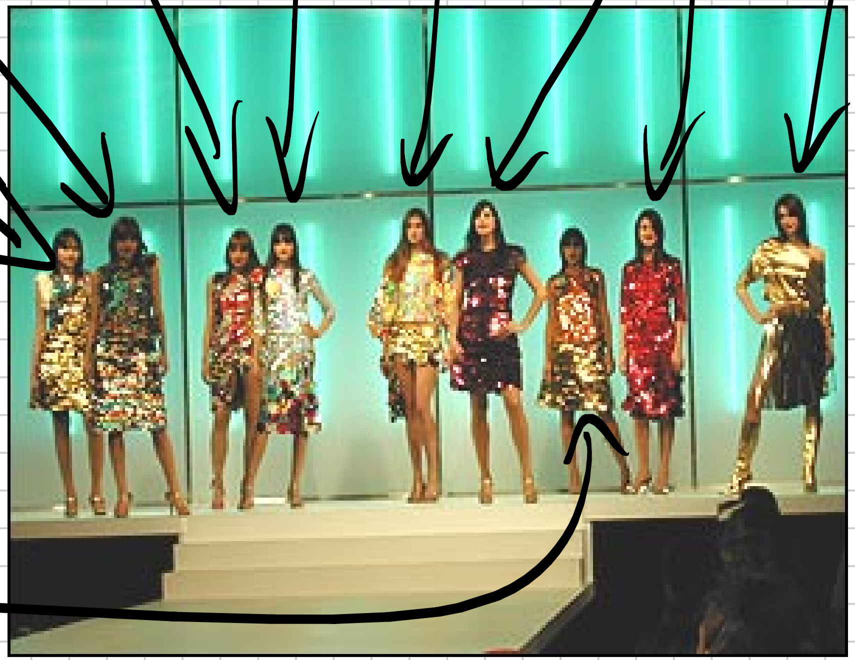
VI Putting things together

Intermezzo: On the catwalk

Models all over the place!

(Inf.)
Execution models
- Paths / Traces
- Trees
- Simulation runs

?



Intermc220: What concepts have we seen so far.

Syntax for Models:
- Language-based: Process Algebra
- Graphical: Automata + Composition

Model Ingrediants:
- Probalities
- Delays (random vs. nondeterministic)
- Actions (action nondeterminism)
- Costs

Analysis techniques:
- Model Checking (CTL)
- Equivalence Checking (Bisimulation)
- Numerial Analysis
- Discrete Event simulation

B) Semantics of Modest

0th-approxination (only "par")

$$\mathrm{par}\{:: P_1 \ldots :: P_n\} \stackrel{def}{=} \left(\ldots \left(\left(P_1 \parallel_{B_1} P_2 \right) \parallel_{B_2} P_3 \right) \ldots \right) \parallel_{B_{n-1}} P_n$$

whve $B_j = \left(\bigcup_{i=1}^{j} \alpha(P_i) \right) \cap \alpha(P_{j+1})$

The Alphabet of a process

$$\alpha(\text{stop}) = \alpha(\text{break}) = \emptyset \qquad \alpha(\text{act}) = \{\text{act}\} \setminus \{J\}$$

$$\alpha(\text{act palt}\{:: w_1 : P_1 \dots w_n : P_n\}) = \alpha(\text{act}) \cup \bigcup_{i=1}^{n} \alpha(P_i)$$

$$\alpha(\text{when}(b)\, P) = \alpha(\text{urgent}(b)\, P) = \alpha(P)$$

$$\alpha(\text{alt}\{:: P_1 \dots :: P_n\}) = \alpha(\text{do}\{:: P_1 \dots :: P_n\}) = \alpha(\text{par}\{:: P_1 \dots :: P_n\}) = \bigcup_{1}^{n} \alpha(P_i)$$

$$\alpha(P_1 ; P_2) = \alpha(P_1) \cup \alpha(P_2)$$

$$\alpha(\text{relabel}\{a_1 \dots a_k\} \text{ by } \{a'_1 \dots a'_k\}\, P) = [a_1 \mapsto a'_1, \dots, a_k \mapsto a'_k]\, \alpha(P) \setminus \{J\}$$

$$\alpha(\text{extend}\{a_1 \dots a_k\}\, P) = \alpha(P) \cup \{a_1, \dots, a_k\}$$

C Semantic Model: Stochastic Timed Automata

First approximation:

Transitions are labelled by:

- an action "a" to be performed
- a guard "g" indicating when transition is enabled
- a deadline "d" indicating when transition must ultimately be taken
- a set "A" of assignments to be carried out atomically.

$$\bullet \xrightarrow{a,\,g,\,d,\,A}$$

[illegible] Variables, Expressions and Assignments

Without bothering about details, we assume

- a set "Var" of typed variables
  including a set "Ck" of clock variables
- a set "Exp" of expressions over variables
  including a set "BExp" of boolean expressions
- a set "Assign" of assignments, i.e. functions which
  map variables to expressions.

D] Semantics, first approximation

Basic actions:

successfull termination

$$\frac{}{act \xrightarrow{act,\, tt,\, ff,\, \emptyset} \checkmark}$$

$$act \xrightarrow{act,\, tt,\, ff} D\,(\emptyset, \checkmark)$$

$$\frac{}{break \xrightarrow{b,\, tt,\, ff,\, \emptyset} \checkmark}$$

Choice:

$$\frac{P_i \xrightarrow{a,\, g,\, d,\, A} P' \quad (0 < i \leq n)}{alt\{:: P_1 \dots :: P_n\} \xrightarrow{a,\, g,\, d,\, A} P'}$$

Sequencing:

$$\frac{P \xrightarrow{a,\, g,\, d,\, A} P' \qquad P' \neq \checkmark}{P;\, Q \xrightarrow{a,\, g,\, d,\, A} P';\, Q}$$

$$\frac{P \xrightarrow{a,\, g,\, d,\, A} \checkmark}{P;\, Q \xrightarrow{a,\, g,\, d,\, A} Q}$$

Loop: $\quad do\{\tilde{P}\} \stackrel{def}{=} auxdo\{alt\{\tilde{P}\}\}\{alt\{\tilde{P}\}\}$

$:: P_n \ldots :: P_n = \tilde{P}$

$$\frac{P \xrightarrow{a,g,d,A} \checkmark \qquad (a \neq \overset{\text{break}}{b})}{auxdo\{P\}\{Q\} \xrightarrow{a,g,d,A} auxdo\{Q\}\{Q\}}$$

$$\frac{P \xrightarrow{b,g,d,A} P'}{auxdo\{P\}\{Q\} \xrightarrow{\tau,g,d,A} \checkmark}$$

$$\frac{P \xrightarrow{a,g,d,A} P' \qquad (a \neq b) \wedge (P' \neq \checkmark)}{auxdo\{P\}\{Q\} \xrightarrow{a,g,d,A} auxdo\{P'\}\{Q\}}$$

Conditions:

$$\frac{P \xrightarrow{a,\, g,\, d,\, A} P'}{\mathrm{when}(b)\, P \xrightarrow{a,\ b \wedge g,\ d,\ A} P'}$$

$$\frac{P \xrightarrow{a,\, g,\, d,\, A} P'}{\mathrm{urgent}(b)\, P \xrightarrow{a,\ g,\ b \vee d,\ A} P'}$$

Par:
$$\frac{P_1 \xrightarrow{a,\,g,\,d,\,A} P'}{P_1 \parallel_B P_2 \xrightarrow{a,\,g,\,d,\,A} P' \parallel_B P_2} \quad (a \notin B)$$

where $(\checkmark \parallel_B \checkmark)$ reduces to $\checkmark$

und symmetrisch

$$\frac{P_1 \xrightarrow{a,\,g_1,\,d_1,\,A_1} P_1' \;\wedge\; P_2 \xrightarrow{a,\,g_2,\,d_2,\,A_2} P_2' \quad a \in B}{P_1 \parallel_B P_2 \xrightarrow{a,\,g_1 \wedge g_2,\,d_1 \, op \, d_2,\,A_1 \cup A_2} P_1' \parallel_B P_2'}$$

be aware of inconsistent assignments

Patient vs. impatient actions

We assume Act to be split into 3 disjoint subsets:

- PAct: the set of patient actions
- IAct: the set of impatient actions
- $\{J\}$

op $= \wedge$

op $= \vee$

E | True semantics

The model of Stochastic Timed Automata truly is:

a quadruple $(Loc, Act, \rightarrow, P)$, where

- "Loc" is the set of expressions readable from "P" via "$\rightarrow$"

locations

- Act is as before,
- P is the initial location

$$W : (Axp \times Loc) \rightarrow \mathbb{R}$$

- $\rightarrow \subseteq Loc \times (Act \times Bxp \times Bxp) \times Wxp$, where

Wxp is the set of all weighted pairs of assignments and successor-location

For more on the true semantics, see the MoDest paper

Semantics of palt:

$$\text{act palt}\{:w_1: assgn_1; P_1 \ldots :w_k: assgn_k; P_k\} \xrightarrow{act,\ tt,\ ff} \mathcal{W}$$

whith $\mathcal{W}(A,P) = \begin{cases} \sum_{j=1}^{k} I(i,j) \cdot w_j, & \text{if } (A,P) = (assgn_i, P_i) \\ 0, & \text{otherwise} \end{cases}$

for $0 < i \leq k$

where $I(i,j) = \begin{cases} 1 & \text{if } (assgn_i, P_i) = (assgn_j, P_j) \\ 0 & \text{otherwise.} \end{cases}$

multi-transition problem.

$\boxed{F}$ Expressiveness of STA

	LTS	TA	DTMC	CTMC	GSMP	STA
probabilistic branching	−	−	+	+	+	+
clocks	−	+	−	Restricted	+	+
random delays	−	−	− (geometric)	Exp. dist	+	+
delay nondeterminism	−	+	−	−	−	+
action nondeterminism	+	+	−	−	−	+
						+