ACTIMS ETH Zurich 2014
Opening

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Not possible without

- Rodrigo Castro
- Andreas Fischlin
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- Olivier Michel
- Gabriel Wainer
Workshop concept

- On invitation only
- Interdisciplinary (robots, biology, etc.)
- Work together, share ideas, make them emerge...
- Avoid the problems of large-scope conference
- Focus on M&S activity
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Win-win publications

- **Proceedings**
  - Play the game of collective involvement
  - Minimum participation *threshold*

- Special issue in International Journal of Modeling, Simulation, and Scientific Computing (IJMSSC, depends on *threshold*)

- Group article in CISE IEEE Magazine
  (technical but high level ;-)
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Usual activity definition I

**Definitions**

*Usual qualitative definition*, “start from an event and end with another” (*Balci)*:

- Example: Fisherman

![Diagram]

- Move
- Fish
- Return
Usual activity definition II

Piecewise constant segment $\omega : [t_1, t_n] \rightarrow P$, where $P$ is the set of activities/ phases, and $\omega_{[t_{i-1}, t_i]}(t) = p_i$ for all $t \in [t_{i-1}, t_i]$.

**Figure:** Piecewise constant segment.
Activity Measure: Number of events

Definitions

Activity is a quantitative measure of the event rate, or event frequency, in an event set (about quantity)

\[ \xi = \{ ev_i = (t_i, v_i) \mid i = 1, 2, 3, \ldots \}, \text{ for } 0 \leq t_i < T. \]

Event-based activity \( A_\xi(T) \):

\[ A_\xi(T) = |\{ ev_i = (t_i, v_i) \in \xi \mid 0 \leq t_i < T \}| \]

Average event-based activity consists then of \( \overline{A_\xi(T)} = \frac{A_\xi(T)}{T} \).
Example of event trajectory

$$\xi(t+10) = 0.3, \quad \xi(t+20) = 0.15, \quad \xi(t+30) \approx 0.133, \quad \xi(t+40) = 0.175.$$
A basic Discrete Event System Specification (DEVS) is a structure:

$$DEVS = (X, Y, S, \delta_{ext}, \delta_{int}, \lambda, ta)$$

Where, $X$ is the set of input events, $Y$ is the set of output events, $S$ is the set of partial states, $\delta_{ext} : Q \times X \rightarrow S$ is the external transition function with $Q = \{(s, e) | s \in S, 0 \leq e \leq ta(s)\}$ the set of total states, $\delta_{int} : S \rightarrow S$ is the internal transition function, $\lambda : S \rightarrow Y$ is the output function, and $ta : S \rightarrow \mathbb{R}_\infty^{0,+}$ is the time advance function.
A *DEVS* network is a structure:

\[ N = (X, Y, D, \{ M_d \}, \{ I_d \}, \{ Z_{i,d} \}, \text{Select}) \]

Where \( X \) is the set of input events, \( Y \) is the set of output events, \( D \) is the set of component names, for each \( d \in D \), \( M_d \) is a basic model, for each \( d \in D \cup \{ N \} \), \( I_d \) is the set of *influencers* of \( d \) such that \( I_d \subseteq D \cup \{ N \} \), \( d \notin I_d \) and for each \( i \in I_d \): \( Z_{i,d} \) is the *coupling function*, and \( \text{Select} : 2^D \setminus \{ \emptyset \} \rightarrow D \cup \{ \emptyset \} \) is the *select function*.
Activity in DEVS

- **Average external activity** \( A_{\text{ext}}(T) \), related to the counting, \( n_{\text{ext}} \), of external transitions \( \delta_{\text{ext}}(s, e, x) \), over a time period \( T \):

\[
\begin{align*}
  s' &= \delta_{\text{ext}}(s, e, x) \Rightarrow n'_{\text{ext}} = n_{\text{ext}} + 1 \\
  A_{\text{ext}}(T) &= \frac{n_{\text{ext}}}{T}
\end{align*}
\]

- **Average internal activity** \( A_{\text{int}}(T) \), related to the counting, \( n_{\text{int}} \), of internal transitions \( \delta_{\text{int}}(s) \), over a time period \( T \):

\[
\begin{align*}
  s' &= \delta_{\text{int}}(s, e) \Rightarrow n'_{\text{int}} = n_{\text{int}} + 1 \\
  A_{\text{int}}(T) &= \frac{n_{\text{int}}}{T}
\end{align*}
\]

- **Total average activity is equal to**:

\[
A_s(T) = A_{\text{ext}}(T) + A_{\text{int}}(T)
\]
Activity in DEVS

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- **Average external activity** $\overline{A_{ext}(T)}$, related to the counting, $n_{ext}$, of external transitions $\delta_{ext}(s, e, x)$, over a time period $T$:

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  \end{align*}$$

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  \end{align*}$$

- **Total average activity is equal to:**

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Abstract simulator

1: variables
2: \( tl \) — time of last event
3: \( tn \) — time of next event
4: \textbf{when} receive \(*\)-message \((*, t)\) at time \( t \)
5: \textbf{if} \((t = tn)\) \textbf{then}
6: \( y = \lambda(s) \)
7: send \( y \)-message \((y, t)\) to parent coordinator
8: \( s = \delta_{\text{int}}(s) \)
9: \( n'_{\text{int}} = n_{\text{int}} + 1 \)
10: \textbf{when} receive \( x \)-message \((x, t)\)
11: \textbf{if} \((x \neq \emptyset \text{ and } tl \leq t \leq tn)\) \textbf{then}
12: \( s = \delta_{\text{ext}}(s, x, e) \)
13: \( n'_{\text{ext}} = n_{\text{ext}} + 1 \)
Weighted activity in DEVS

- **Average external weighted activity** $A_{\text{ext}}^w(T)$, related to the counting, $n_{\text{ext}}$, of external transitions $\delta_{\text{ext}}(s, e, x)$, over a time period $T$:

$$
\begin{align*}
  s' &= \delta_{\text{ext}}(s, e, x) \\
  n_{\text{ext}}' &= n_{\text{ext}} + w_{\text{ext}}(s, e, x) \\
  A_{\text{ext}}^w(T) &= \frac{n_{\text{ext}}}{T}
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- **Average internal weighted activity** $A_{\text{int}}^w(T)$, related to the counting, $n_{\text{int}}$, of internal transitions $\delta_{\text{int}}(s)$, over a time period $T$:

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- **Total average weighted activity** is equal to:

$$
A_s^w(T) = A_{\text{ext}}^w(T) + A_{\text{int}}^w(T)
$$
**Weighted activity in DEVS**

- **Average external weighted activity** $\overline{A^w_{\text{ext}}(T)}$, related to the counting, $n_{\text{ext}}$, of external transitions $\delta_{\text{ext}}(s, e, x)$, over a time period $T$:

  $\begin{cases} 
  s' = \delta_{\text{ext}}(s, e, x) \Rightarrow n'_{\text{ext}} = n_{\text{ext}} + w_{\text{ext}}(s, e, x) \\
  \overline{A^w_{\text{ext}}(T)} = \frac{n_{\text{ext}}}{T}
  \end{cases}$

- **Average internal weighted activity** $\overline{A^w_{\text{int}}(T)}$, related to the counting, $n_{\text{int}}$, of internal transitions $\delta_{\text{int}}(s)$, over a time period $T$:

  $\begin{cases} 
  s' = \delta_{\text{int}}(s, e) \Rightarrow n'_{\text{int}} = n_{\text{int}} + w_{\text{int}}(s) \\
  \overline{A^w_{\text{int}}(T)} = \frac{n_{\text{int}}}{T}
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- **Total average weighted activity** is equal to:

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Weighted activity in DEVS

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- **Total average weighted activity** is equal to:

\[
A_{s}^w(T) = A_{\text{ext}}^w(T) + A_{\text{int}}^w(T)
\]
Activity of a network

Definition

*Average simulation activity of a network* $N$ is the sum of average simulation activities of components $i \in D$ in $N$:

$$\bar{A}_{s,N} = \sum_{i \in D} A_{s,i}(t' - t).$$
Continuous activity

\[ A_c(T) = \int_0^T \left| \frac{\partial \Phi(t)}{\partial t} \right| \, dt \approx \sum_{i=1}^n \left| m_i - m_{i+1} \right| \]

Average continuous activity consists then of \( \overline{A_c(T)} = \frac{A_c(T)}{T} \).
Link Events/Transitions and continuous activity

Significant change of value of size $D = |\Phi^{n+1} - \Phi^n|$ (quantum)

Discretization activity $A_d(T)$ is minimum number of transitions necessary for discretizing/approaching the trajectory of $\Phi(t)$

$$A_d(T) = \frac{A_c(T)}{D}$$
Two-dimensional cartesian coordinates

- Fire spread, brain activity...: Activity amplitude (real value), of each coordinate, is represented in the third dimension:
Activity referenced states

Definition

Activity references constitute a viewpoint of the state set where only the variables relevant for activity are selected.

- We consider sub-sets of the state set: \( Q = \prod_{i=0}^{n} E_i \), with \( E_i \): Any set with \( n \) the number of sets. Ex: \( Q = \mathbb{R} \times \mathbb{N} \times \mathbb{R} \), and a possible state would be \( q = (68.2, 20, 381.5) \).
- Set of activity referenced states: \( G_I = \pi_I(Q) = \prod_{i \in I} E_i \), as a projection of the state space \( Q \) onto indexes \( I \subseteq \{1, ..., n\} \)
- \( \pi \): operator to “select” a subset of the state elements.
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- Set of activity referenced states: $G_l = \pi_l(Q) = \prod_{i \in I} E_i$, as a projection of the state space $Q$ onto indexes $I \subseteq \{1, \ldots, n\}$
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Activity Regions in Activity Referenced States

- Activity region in activity referenced states:

\[
\mathcal{AR}^{G_i}(t) = \{ g \in G_i \mid A_\xi(t) > 0 \}
\]

- Inactivity region in activity referenced states:

\[
\overline{\mathcal{AR}^{G_i}}(t) = \{ g \in G_i \mid A_\xi(t) = 0 \}
\]

- Activity-based partitioning of \( G_i \):

\[
\forall t \in \mathbb{R}^+, \ G_i = \mathcal{AR}^{G_i}(t) \cup \overline{\mathcal{AR}^{G_i}}(t)
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- Activity-based partitioning of \( \mathcal{G}_i \):
  \[
  \forall t \in \mathbb{R}^+, \quad \mathcal{G}_i = \mathcal{AR}^{G_i}(t) \cup \overline{\mathcal{AR}^{G_i}}(t)
  \]
Fire Spread Example

Assume the fire model describes the state of a cell with the following states:
- $x \in \mathbb{R}$ and $y \in \mathbb{R}$;
- $status \in \{ burnt, burning, safe \}$;
- $type \in \{ tree, bush, water, road \}$;
- $heat \in \mathbb{R}$.

A simple model of the activity regions can involve the status and the type of the cell. Formally, the set of activity referenced states would be $G_{2,3}$. The resulting activity region specification would be

$$AR^{G_{2,3}}(t) = \{\{burning, safe\} \times \{tree, bush\}\}, \forall t \in \mathbb{R}^+$$
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  - $x \in \mathbb{R}$ and $y \in \mathbb{R}$;
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![Diagram showing activity regions for different statuses and types]
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Extension to Activity Generalized Coordinates

**Definitions**

\[
A(g_{\text{max}} - g_{\text{min}}) = \int_{g_{\text{min}}}^{g_{\text{max}}} \left| \frac{\partial \Phi(g)}{\partial g} \right| \, dg
\]

**Example for** \( g = p \)
Perspectives

- Analytic activity (Jean-François and Laurent)
- Continuous activity (Rodrigo and Fernando)
- Evolutionist adaptive systems (Patrick and Laurianne)
- To be discussed at ACTIMS?
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