# ACTIMS ETH Zurich 2014
# Opening

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# Not possible without

- Rodrigo Castro
- Andreas Fischlin
- François Cellier
- Jean-François Santucci
- Laurent Capocchi
- 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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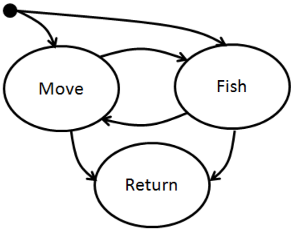
# Usual activity definition I

## Definitions

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

- Example: Fisherman



# Usual activity definition II

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

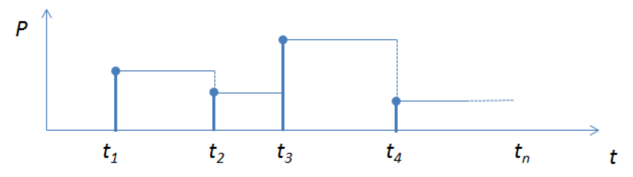



Figure: Piecewise constant segment.

# Activity Measure: Number of events

## Definitions

*Activity is a quantitative measure of the event rate, or event frequency, in an event set* (about quantity)
$\xi = \{ev_i = (t_i, v_i) \mid i = 1, 2, 3, ...\}$, 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

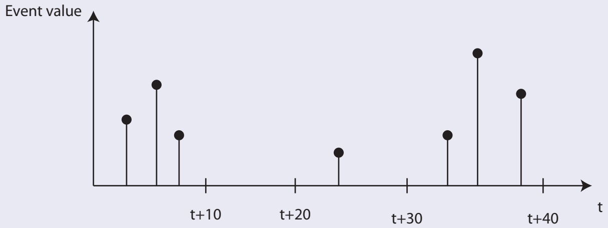



Figure: $\overline{A_\xi(10)} = 0.3$, $\overline{A_\xi(20)} = 0.15$, $\overline{A_\xi(30)} \simeq 0.133$, $\overline{A_\xi(40)} = 0.175$.

# DEVS

## Definition

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 $ta : S \rightarrow \mathbb{R}^{0,+}_{\infty}$ is the *time advance function.*

# Network

## Definition

A *DEVS* network is a structure:

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

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 $Select : 2^D - \{\emptyset\} \rightarrow D \cup \{\emptyset\}$ is the *select function*.

# Activity in DEVS

- *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 $T$:

$$\begin{cases} s' = \delta_{ext}(s, e, x) \Rightarrow n'_{ext} = n_{ext} + 1 \\ \overline{A_{ext}(T)} = \frac{n_{ext}}{T} \end{cases}$$

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

$$\begin{cases} s' = \delta_{int}(s, e) \Rightarrow n'_{int} = n_{int} + 1 \\ \overline{A_{int}(T)} = \frac{n_{int}}{T} \end{cases}$$

- *Total average activity* is equal to:

$$\overline{A_s(T)} = \overline{A_{ext}(T)} + \overline{A_{int}(T)}$$

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# Abstract simulator

**variables**
  $tl$ — time of last event
  $tn$ — time of next event
**when** receive *-message $(*, t)$ at time $t$
  **if** $(t = tn)$ **then**
    $y = \lambda(s)$
    send y-message $(y, t)$ to parent coordinator
    $s = \delta_{int}(s)$
    $n'_{int} = n_{int} + 1$
**when** receive x-message (x, t)
  **if** $(x \neq \oslash$ and $tl \leq t \leq tn)$ **then**
    $s = \delta_{ext}(s, x, e)$
    $n'_{ext} = n_{ext} + 1$

# Weighted activity in DEVS

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

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

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# Activity of a network

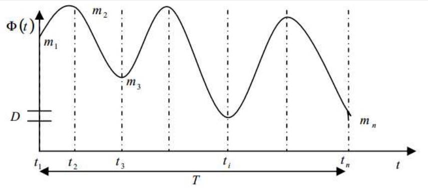
**Definition**

*Average simulation activity of a network N* is the sum of average simulation activities of components $i \in D$ in $N$:
$\overline{A_{s,N}} = \Sigma_{i \in D} \overline{A_{s,i}(t' - t)}$.

# Continuous activity

$$A_c(T) = \int_0^T \left|\frac{\partial \Phi(t)}{\partial t}\right| dt \simeq \Sigma_{i=1}^{n} |m_i - m_{i+1}|$$

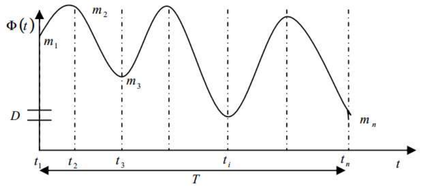
*Average continuous activity* consists then of $\overline{A_c(T)} = \frac{A_c(T)}{T}$ .



# Link Events/Transitions and continuous activity

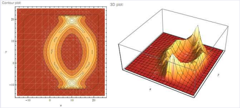
Significant change of value of size $D = \left|\Phi^{n+1} - \Phi^{n}\right|$ (*quantum*)
*Discretization activity $A_d(T)$ is minimum number of transitions* necessary for discretizing/approching the trajectory of $\Phi(t)$

$$A_d(T) = \frac{A_c(T)}{D}$$



# 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: $\mathcal{G}_I = \pi_I(Q) = \prod_{i \in I} E_i$, as a *projection of the state space* $Q$ onto indexes $I \subseteq \{1, ..., n\}$
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# Activity Regions in Activity Referenced States

- Activity region in activity referenced states:

$$\mathcal{AR}^{\mathcal{G}_I}(t) = \{g \in \mathcal{G}_I \mid A_\xi(t) > 0\}$$

- Inactivity region in activity referenced states:

$$\overline{\mathcal{AR}^{\mathcal{G}_I}}(t) = \{g \in \mathcal{G}_I \mid A_\xi(t) = 0\}$$

- Activity-based partitioning of $\mathcal{G}_I$ :

$$\forall t \in \mathbb{R}^+,\ \mathcal{G}_I = \mathcal{AR}^{\mathcal{G}_I}(t) \cup \overline{\mathcal{AR}^{\mathcal{G}_I}}(t)$$

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# 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 $\mathcal{G}_{2,3}$. The resulting activity region specification would be

$$AR^{\mathcal{G}_{2,3}}(t) = \{\{burning, safe\} \times \{tree, bush\}\}, \forall t \in \mathbb{R}^+$$

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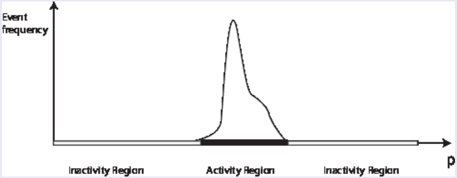
# Extension to Activity Generalized Coordinates

## Definitions

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

## Example for $g = p$



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- Continuous activity (Rodrigo and Fernando)
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