Randomly walking with PDP systems

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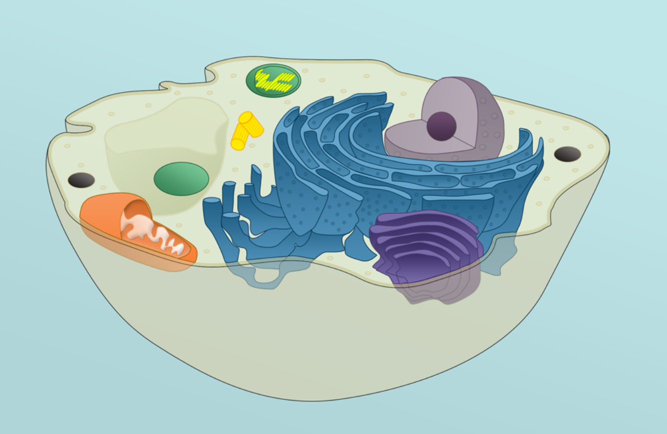
Opava, Czech Republic, August 28th, 2023

Membrane Computing



Types of membrane systems

- Cell-like membrane systems (P systems)

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- Tissue-like membrane systems (Tissue P systems)

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- ...

PDP systems

- Ecosystems

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  Bearded vultures

PDP systems

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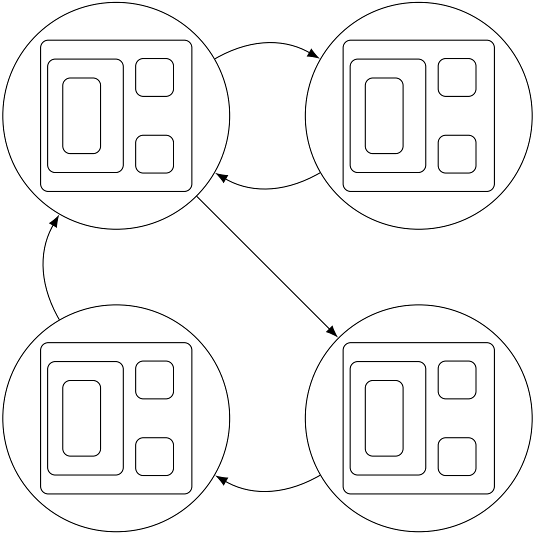
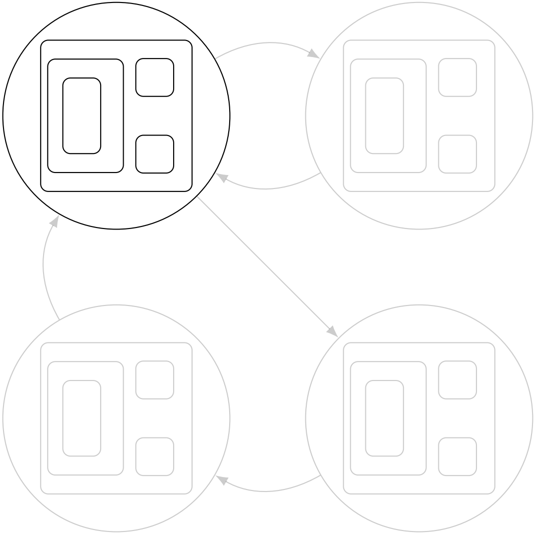
  Uranium 238 decay

  Laser modelling

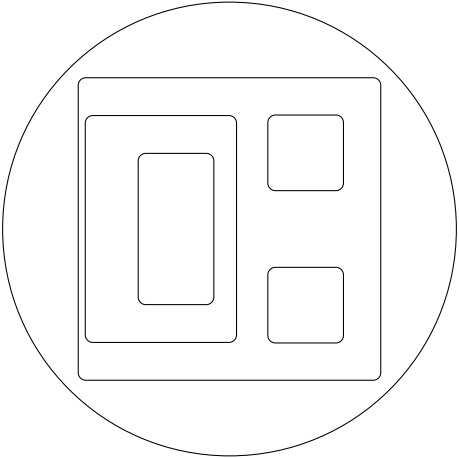
PDP systems



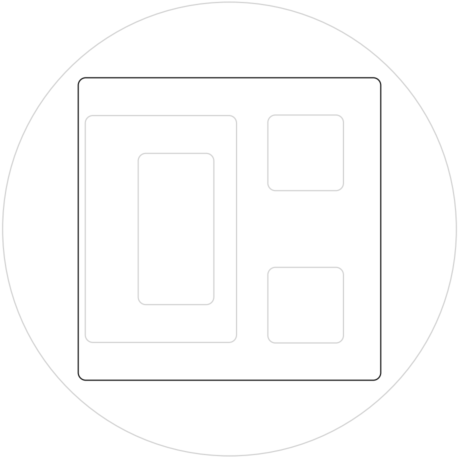
PDP systems



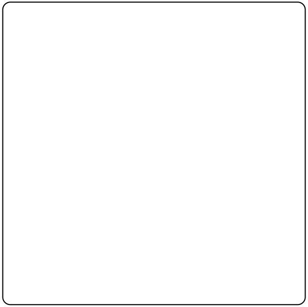
PDP systems



PDP systems



PDP systems



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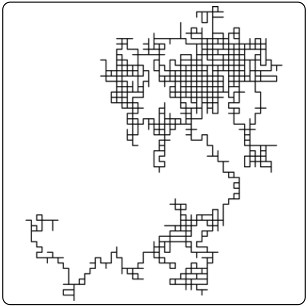
PDP systems



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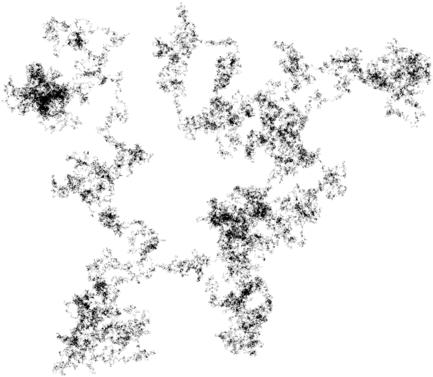
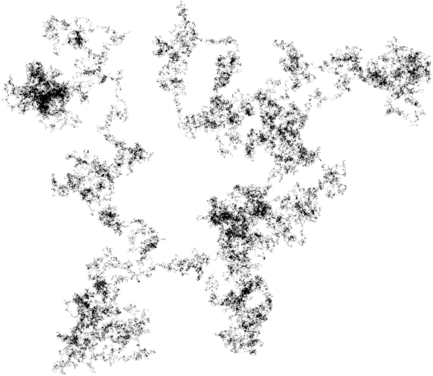
Random walk

- Random process



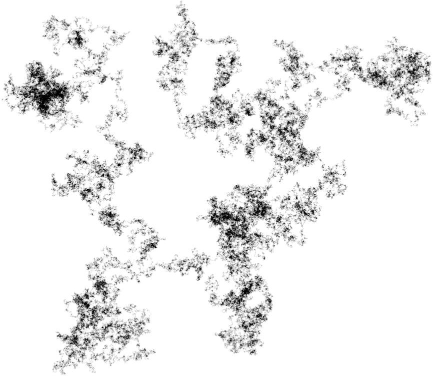
Random walk

- Random process
- *n*-dimensional



Random walk

- Random process
- *n*-dimensional
- Interesting properties



Random walk

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- *n*-dimensional
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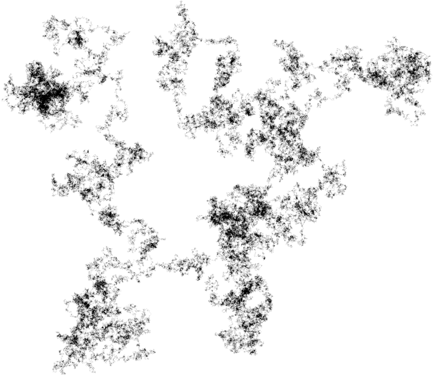
  - Pascal's triangle (1d)



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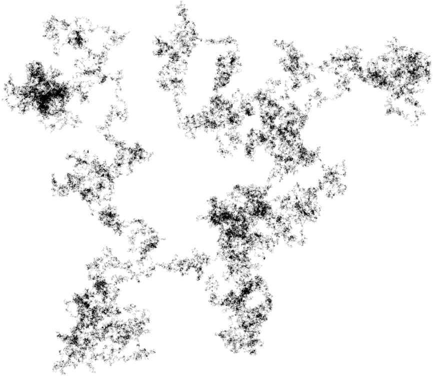

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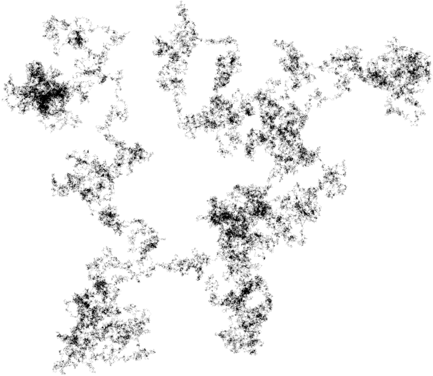
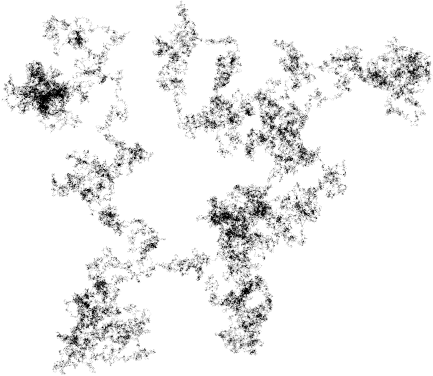
  - Fractals ($>$ 1d)



Random walk

- Random process
- *n*-dimensional
- Interesting properties
  - Pascal's triangle (1d)
  - Markov chain
  - Fractals (> 1d)
  - Wiener process (Brownian motion)



What do we want?

- We want to model *n*-dimensional random walk processes

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$\rightarrow$ We start from the beginning

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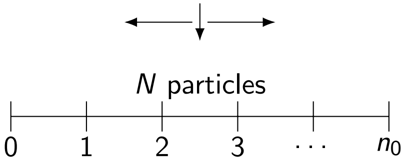
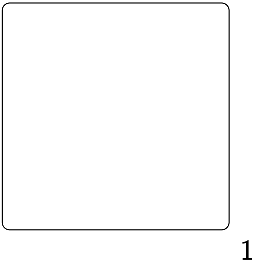
$\rightarrow$ We start from the beginning $\rightarrow$ 1 and 2-dimensional

1D model

- $\Pi = (\Gamma, \mu, \mathcal{M}_1, \mathcal{R}_1)$
- $\Gamma =$



- $\mu = [\quad]_1$
- $\mathcal{M}_1 =$
- $\mathcal{R}_1 =$



1D model

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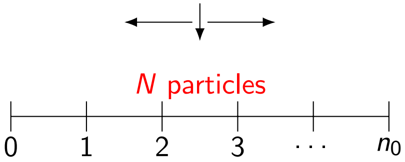
- $\Gamma = \{e_i \mid 0 \leq i \leq N-1\}$



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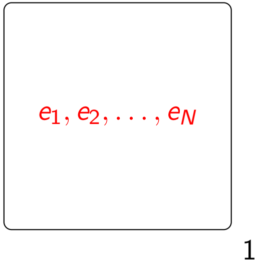
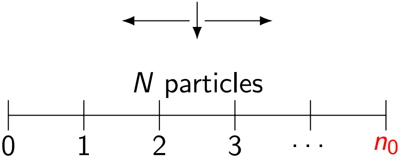


1D model

- $\Pi = (\Gamma, \mu, \mathcal{M}_1, \mathcal{R}_1)$
- $\Gamma = \{e_i \mid 0 \leq i \leq N-1\} \cup \{a_{i,j} \mid 0 \leq i \leq N-1, 0 \leq j \leq n_0\}$



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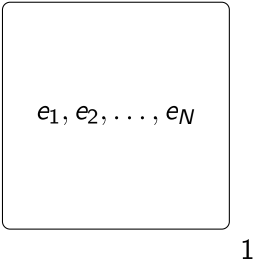

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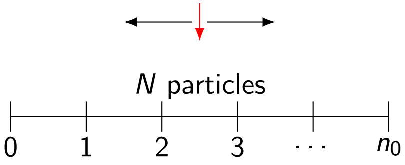
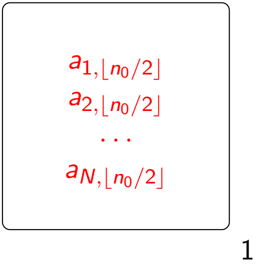
$$[\, e_i \rightarrow a_{i,j} \,]_1$$





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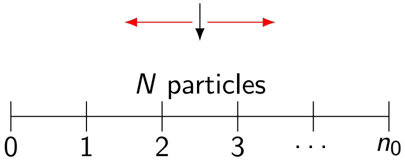
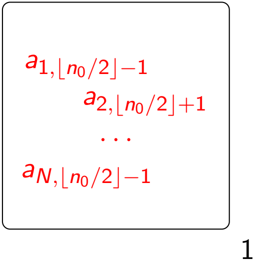
- $\mu = [\ \ ]_1$
- $\mathcal{M}_1 = \{e_i \mid 0 \leq i \leq N-1\}$
- $\mathcal{R}_1 =$

$$[\, e_i \rightarrow a_{i,j} \,]_1 \qquad [\, a_{i,j} \,]_1 \xrightarrow{1/2} [\, a_{i,j+1} \,]_1$$

$$[\, a_{i,j} \,]_1 \xrightarrow{1/2} [\, a_{i,j-1} \,]_1$$





2D model

- $\Pi = (\Gamma, \mu, \mathcal{M}_1, \mathcal{R}_1)$
- $\Gamma = \{e_i \mid 0 \leq i \leq N-1\} \cup \{a_{i,j,k} \mid 0 \leq i \leq N-1, 0 \leq j \leq n_0 - 1, 0 \leq k \leq n_1 - 1\}$
- $\mu = [\ \ ]_1$
- $\mathcal{M}_1 = \{e_i \mid 0 \leq i \leq N-1\}$
- $\mathcal{R}_1 = [\, e_i \rightarrow a_{i,j,k} \,]_1$

$$[\, a_{i,j,k} \,]_1 \xrightarrow{1/4} [\, a_{i,j-1,k} \,]_1$$
$$[\, a_{i,j,k} \,]_1 \xrightarrow{1/4} [\, a_{i,j,k+1} \,]_1$$
$$[\, a_{i,j,k} \,]_1 \xrightarrow{1/4} [\, a_{i,j+1,k} \,]_1$$
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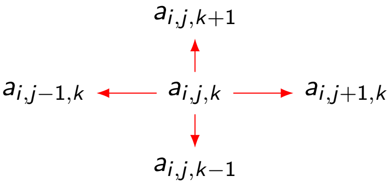

Fixed position?

Instead of $\left[\, e_i \rightarrow a_{i,\lfloor n_0/2 \rfloor} \,\right]_1$, ?

Fixed position?

Instead of $\left[\, e_i \rightarrow a_{i,\lfloor n_0/2 \rfloor} \,\right]_1$,

- Fixed position (initial cell, final cell)

Fixed position?

Instead of $\left[\, e_i \rightarrow a_{i,\lfloor n_0/2 \rfloor} \,\right]_1$,

- Fixed position (initial cell, final cell)
- Experiment position

Fixed position?

Instead of $\left[\, e_i \rightarrow a_{i,\lfloor n_0/2 \rfloor} \,\right]_1$,

- Fixed position (initial cell, final cell)
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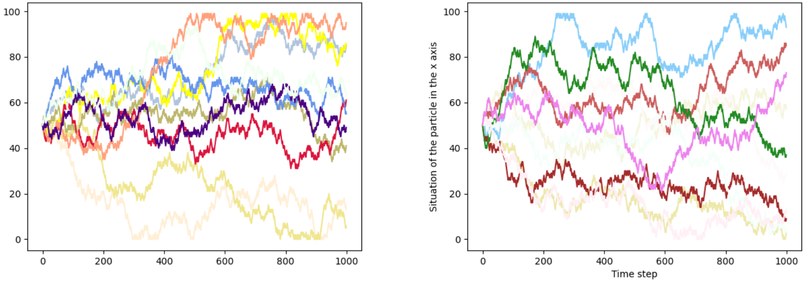
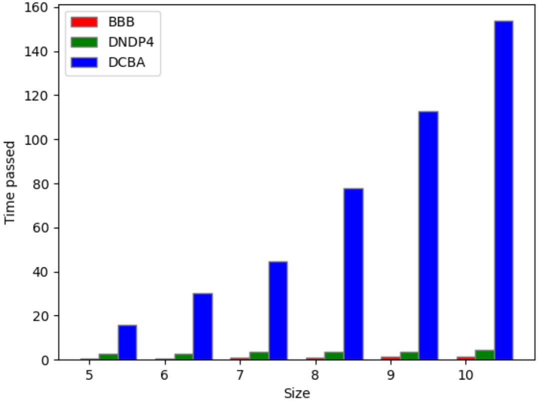
- Random initialization

Simulation



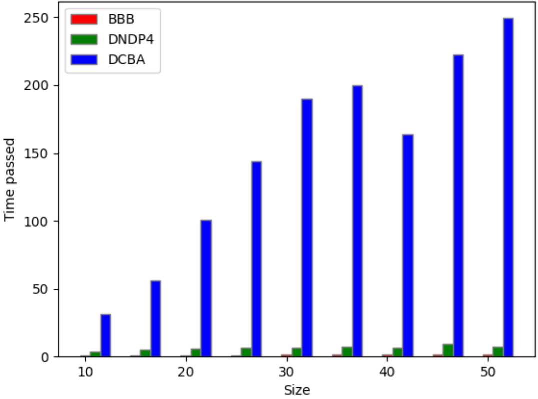
1-dimensional simulation (10 particles, $n_0 = 100$, 1000 steps)

Performance



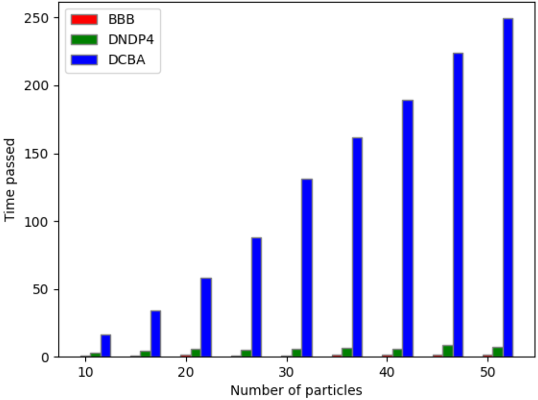
1 dimension, 20 particles, 1000 steps

Performance



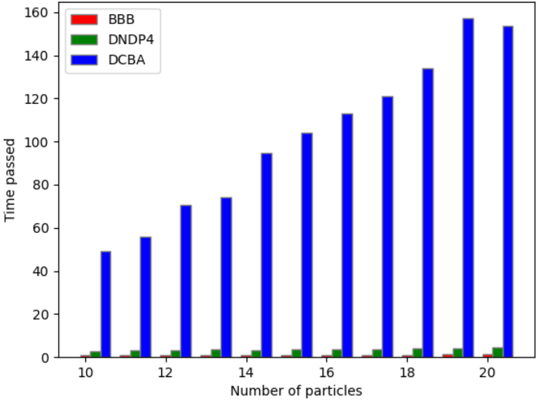
1 dimension, 50 particles, 1000 steps

Performance



1 dimension, $n_0 = 50$, 1000 steps

Performance



2 dimension, $n_0 = 10$, $n_1 = 10$, 1000 steps

Future work

- Initial framework for experiments (Variants, Brownian motion. . .)

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ありがとう

Grazas

Köszönöm

DANKE

Takk

Gràcies

Merci

MULȚUMESC

Děkuju

Eskerrik asko

謝謝

THANKYOU

Gracias

Obrigado

Dankon

Баярлалаа