Spike-Sorting for Interacting Neurons

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FAPESP - CEPID Neuromat

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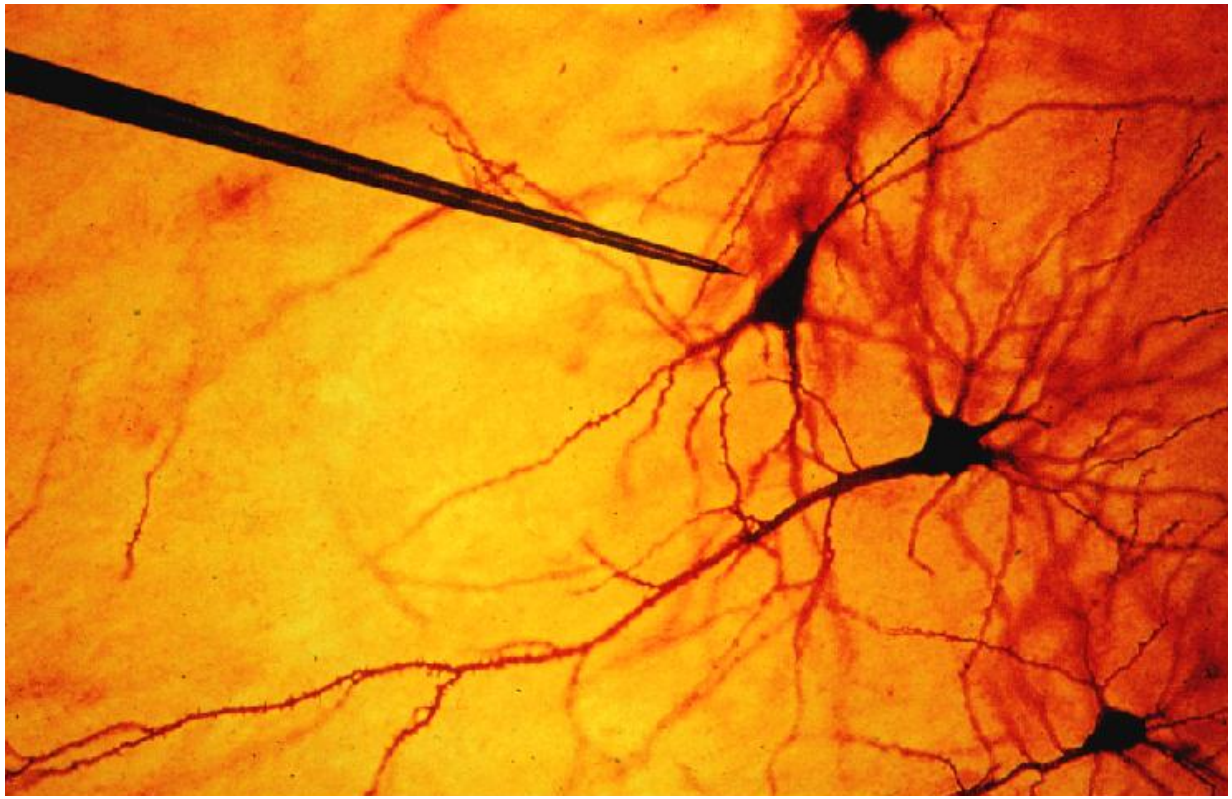
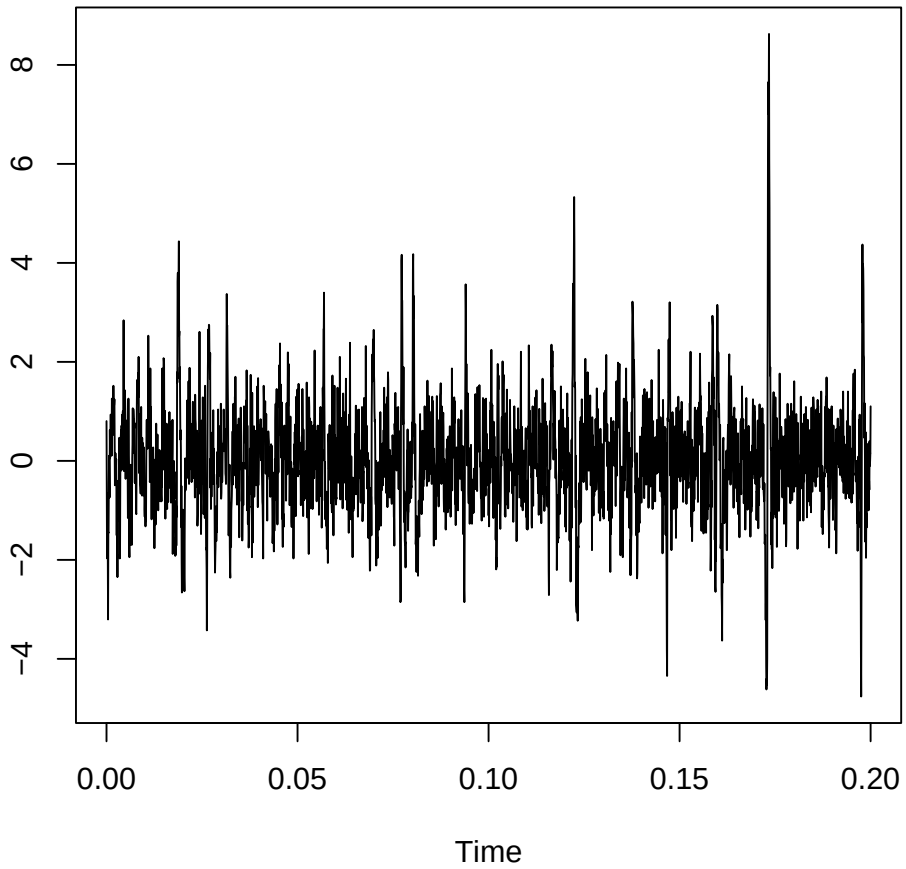
Introduction and Motivation

- Extracellular recordings of brain activity can contain spikes from more than one neuron.
- What we like to do is to distinguish spikes from distinct neurons. This is what we call **spike-sorting.**
- One way to do sorting is use the shape of waveforms collected with the electrodes.
- For 50 years or more people have been doing "reasonable" sorting using only waveform of individual spikes;




8
6
4
2
0
−2
−4
0.00
0.05
0.10
0.15
0.20
Time

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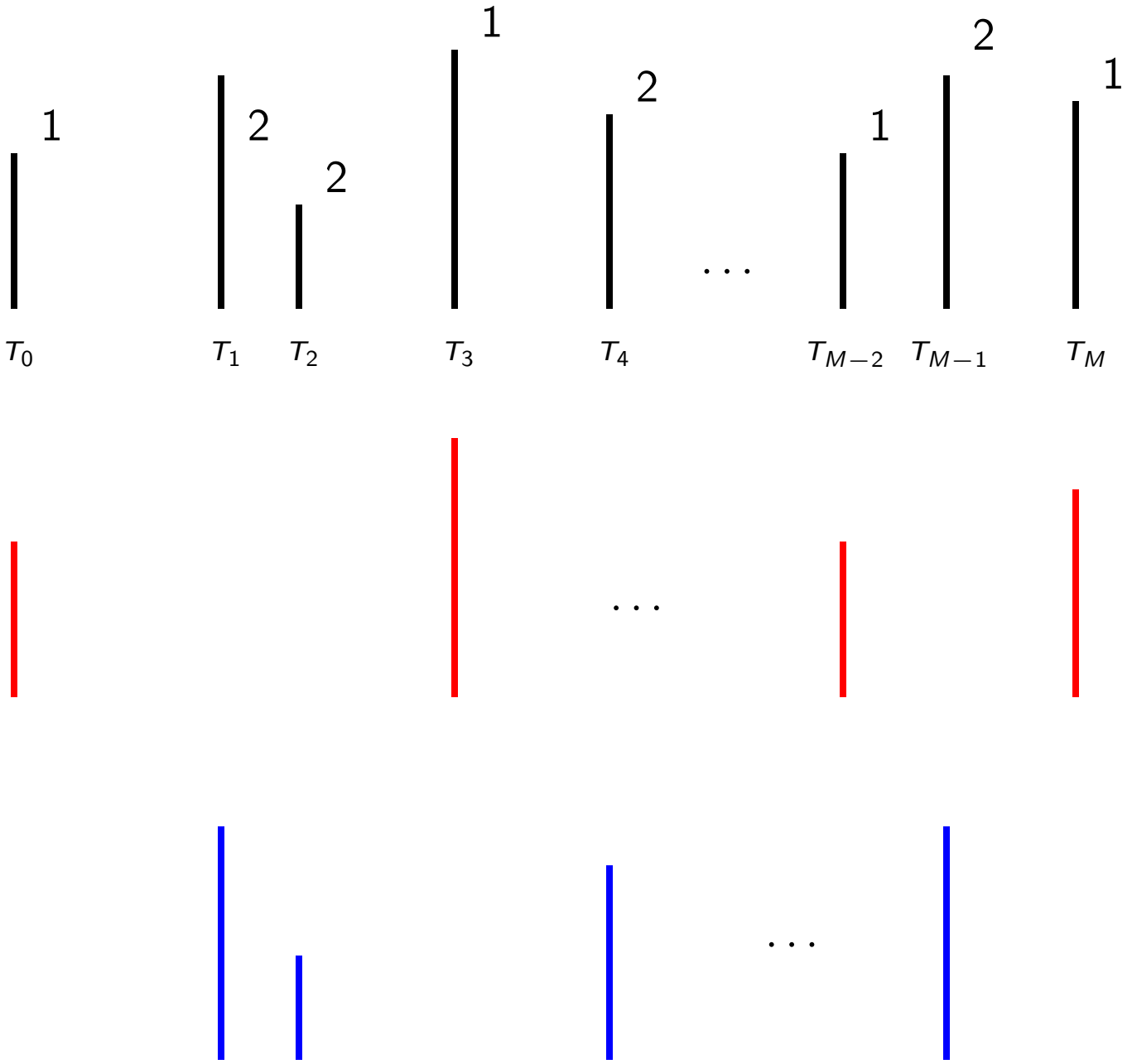
- They didn't include interactions between neurons.


1
1
2
2
1
2
1
2
1
T_0
T_1
T_2
T_3
T_4
T_{M-2}
T_{M-1}
T_M

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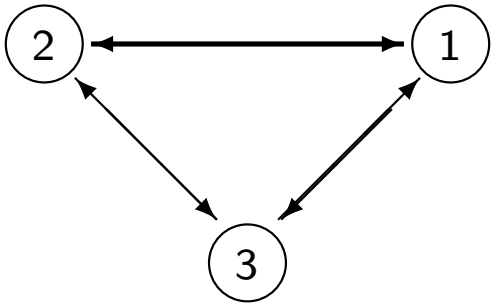
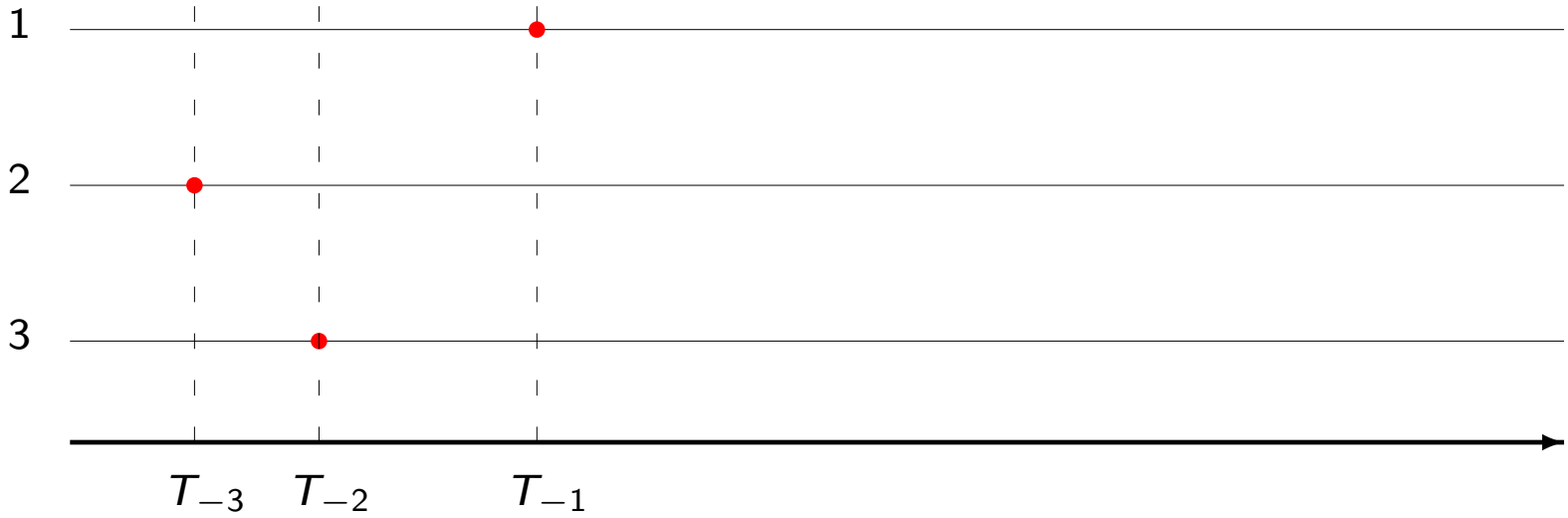
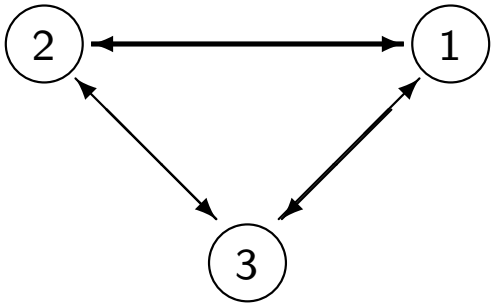
- We want to do statistical model selection to perform spike sorting using only the spike times.



$Y_n = i$, means that the neuron i spikes at time T_n



$Y_{-3}^{-1} = 231$



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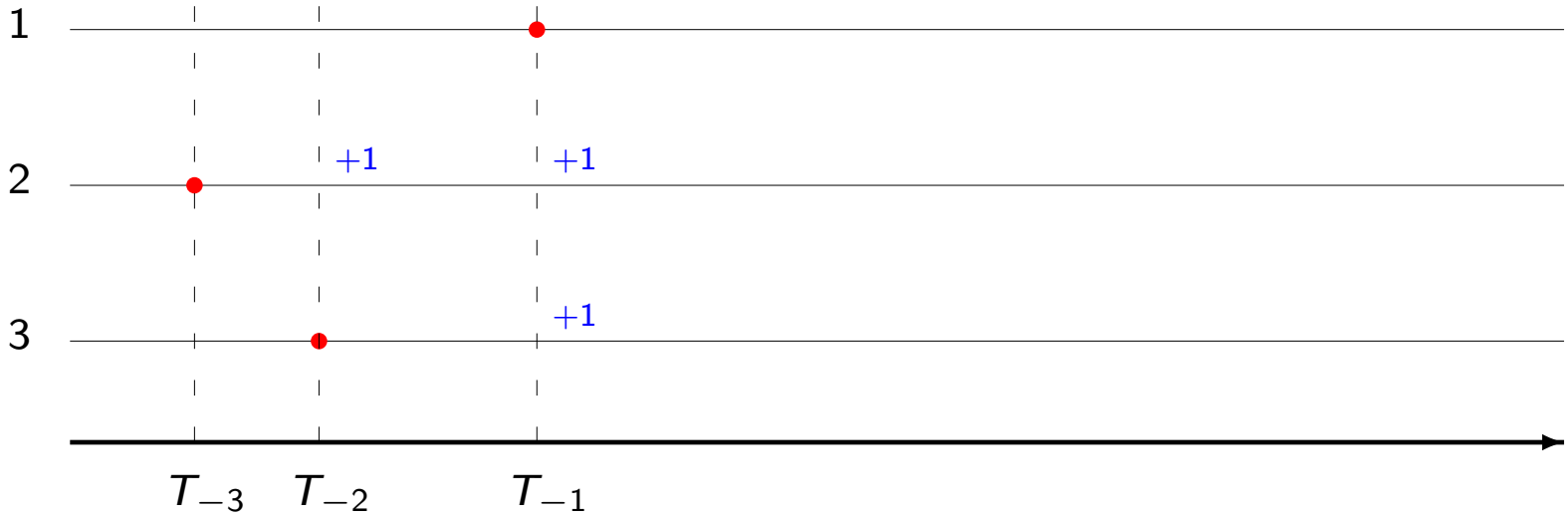

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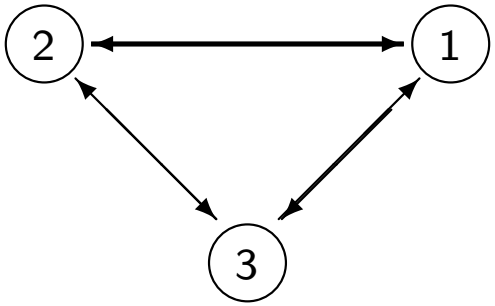

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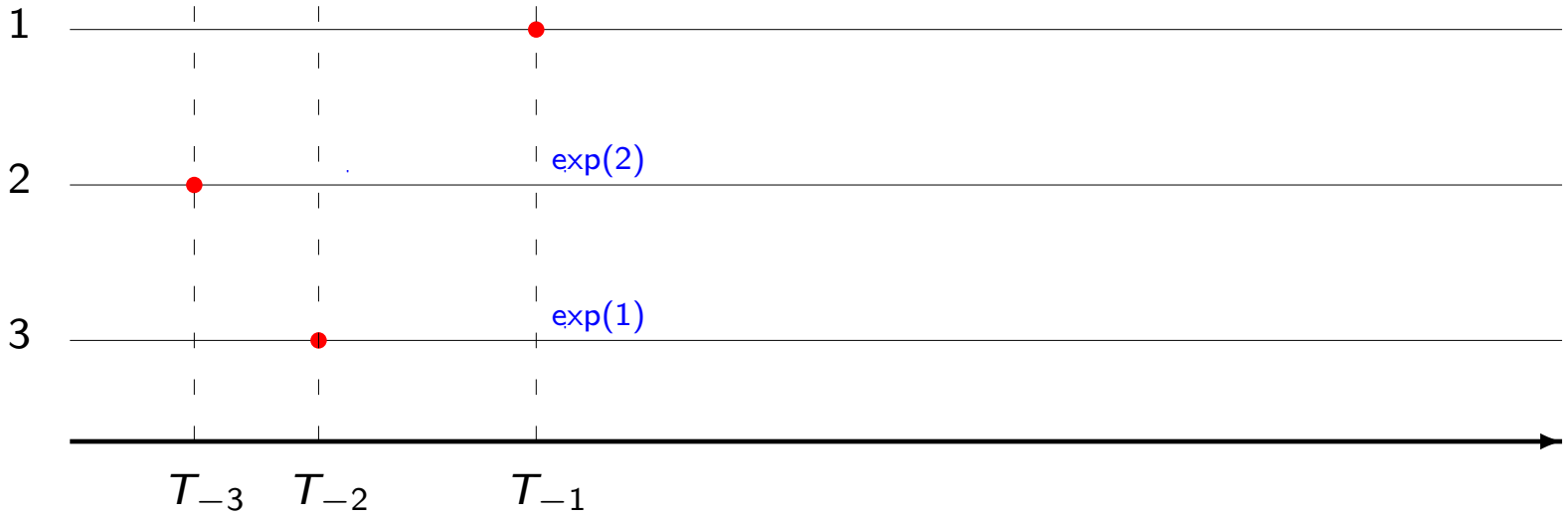

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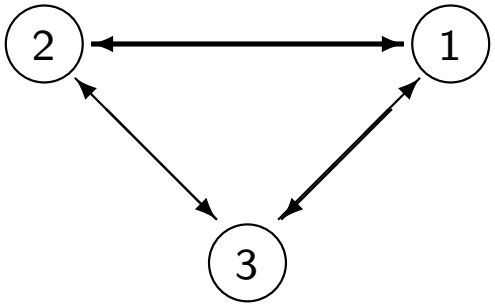

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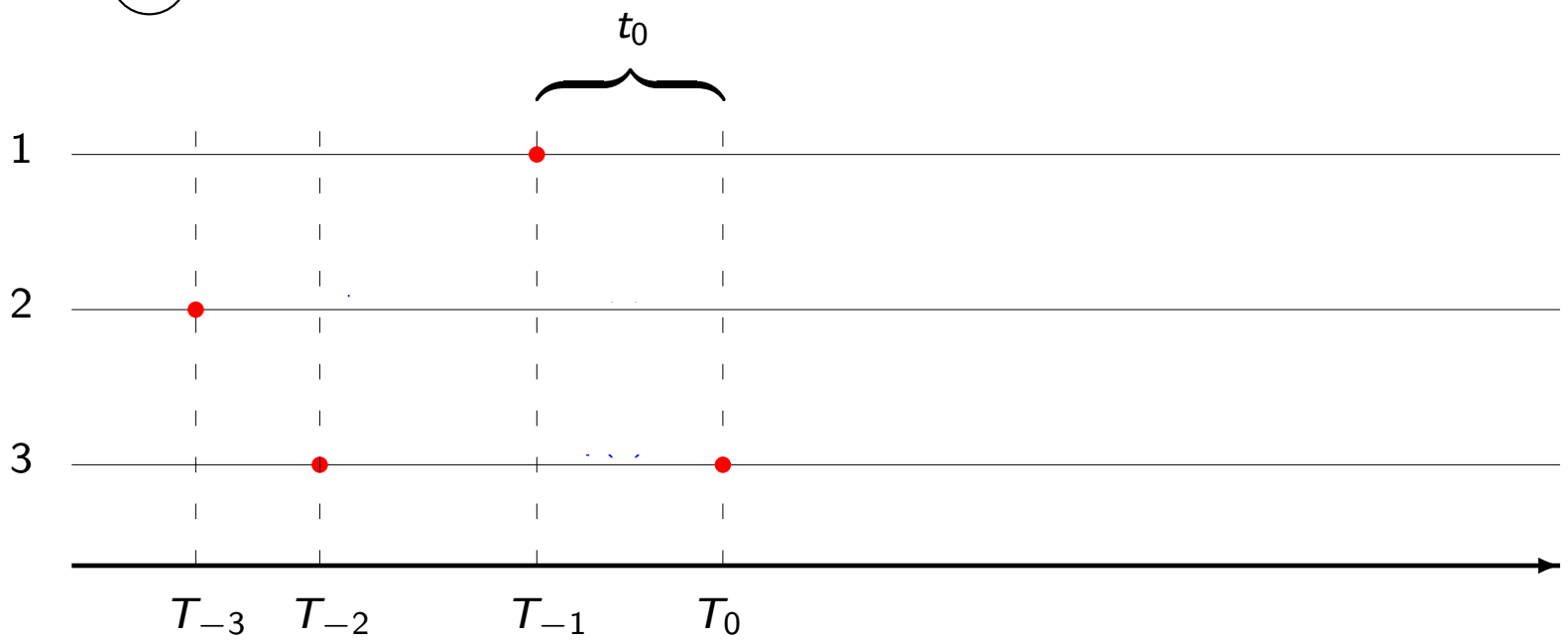

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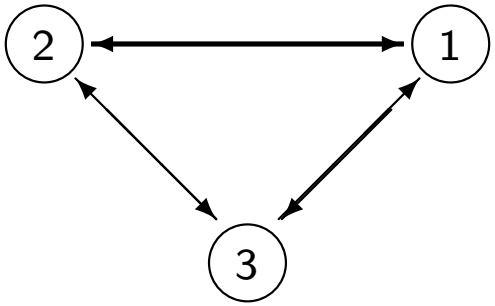

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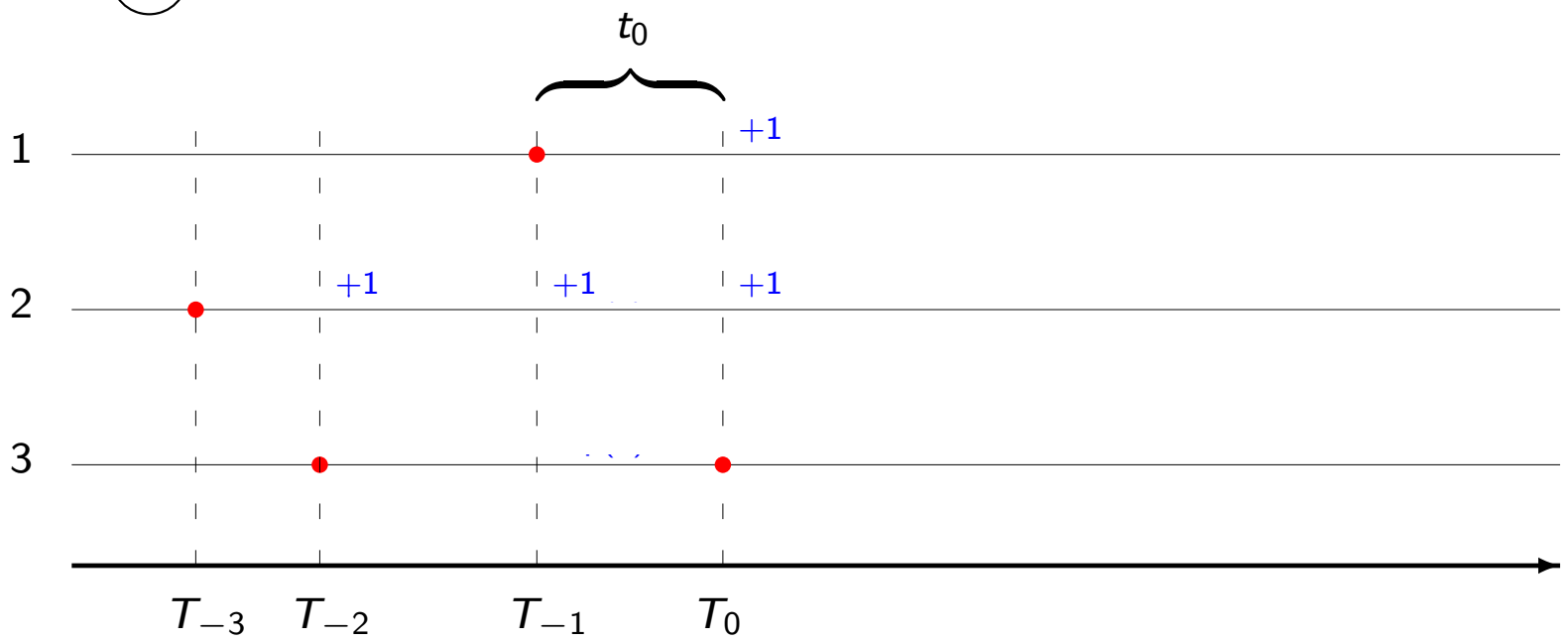

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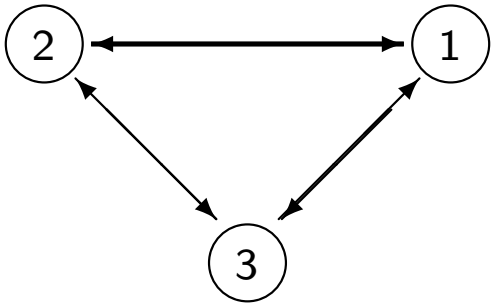

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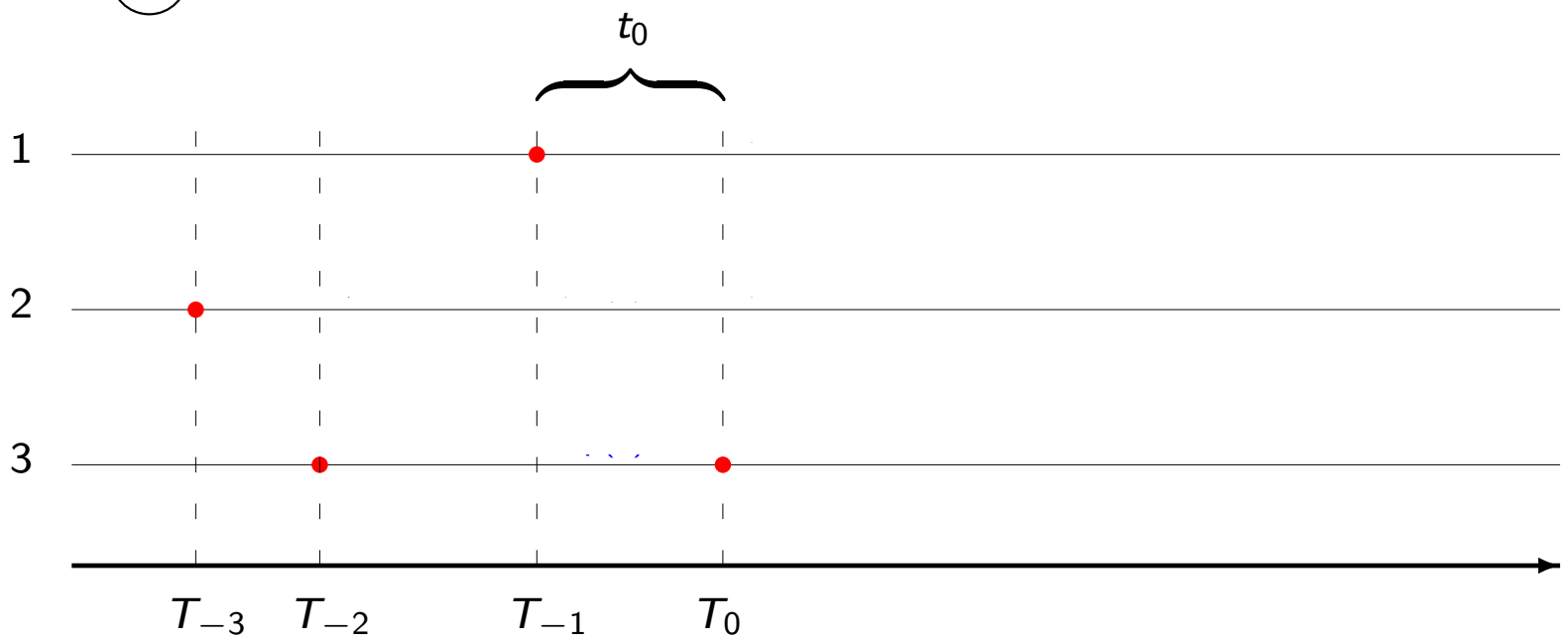

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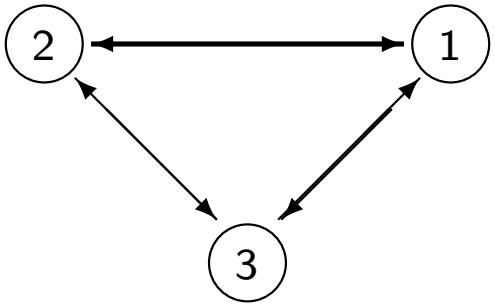

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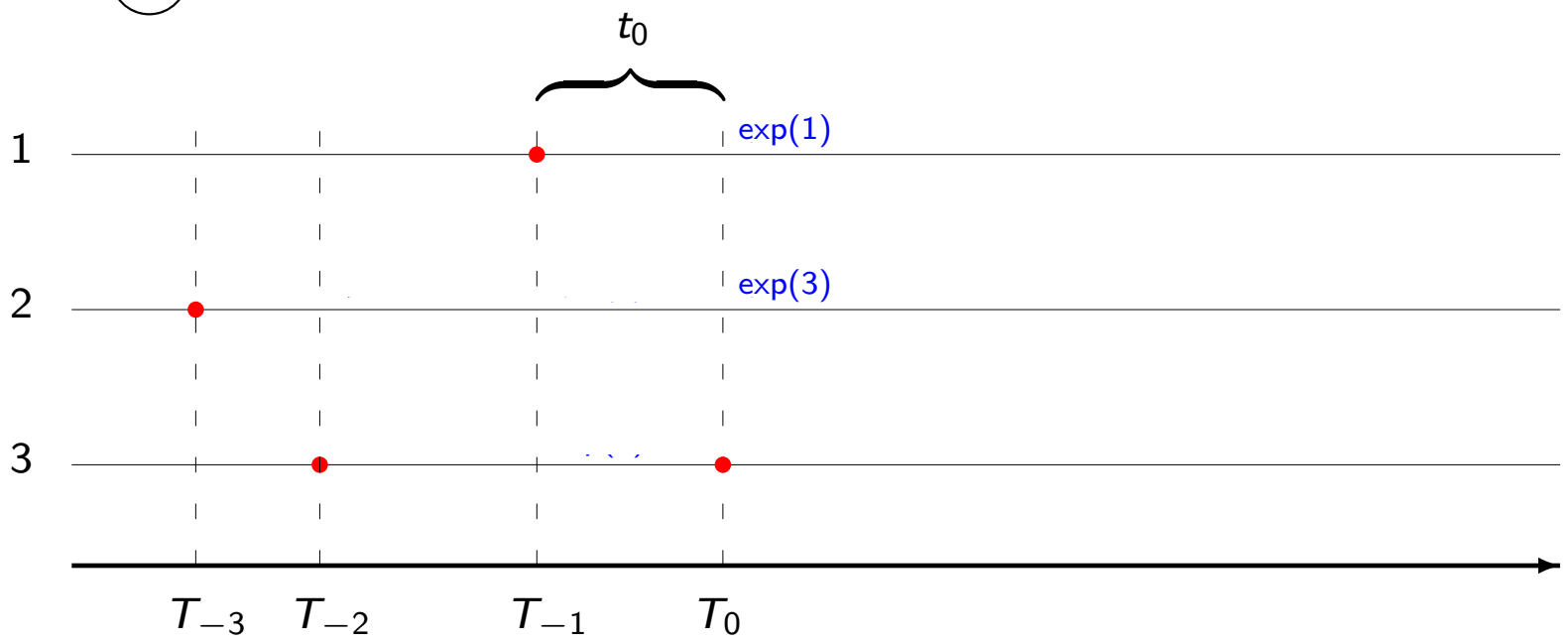

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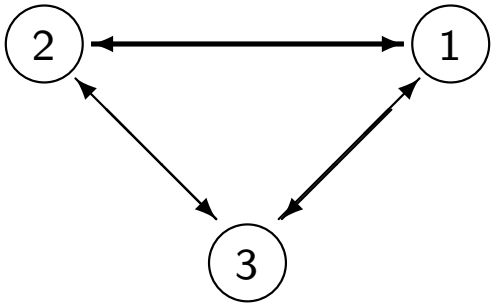

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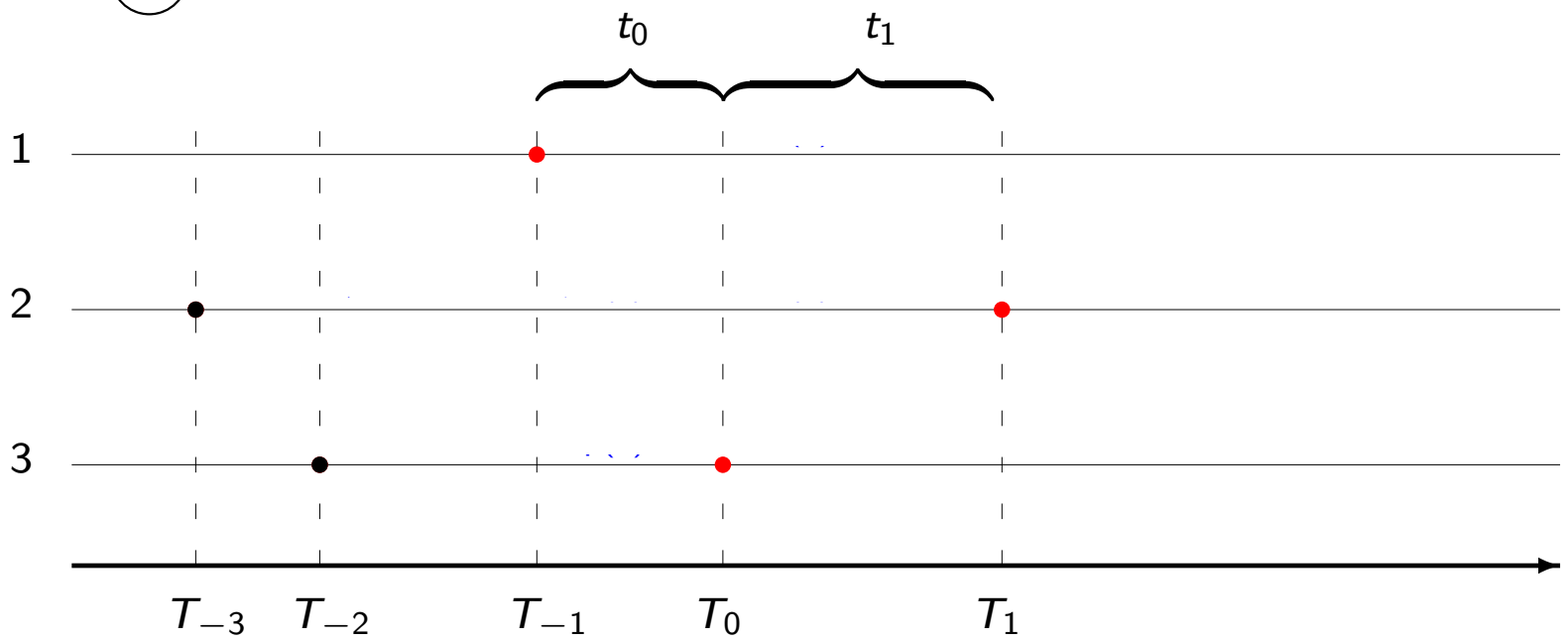
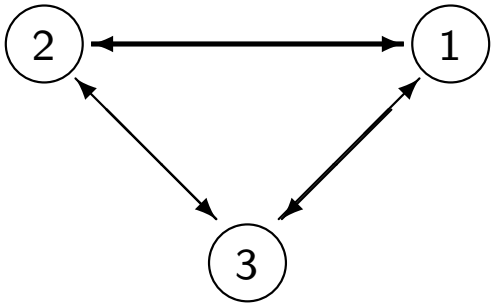


$$Y^1_{-1} = 132$$

$$U_1 = (2, 0, 1)$$



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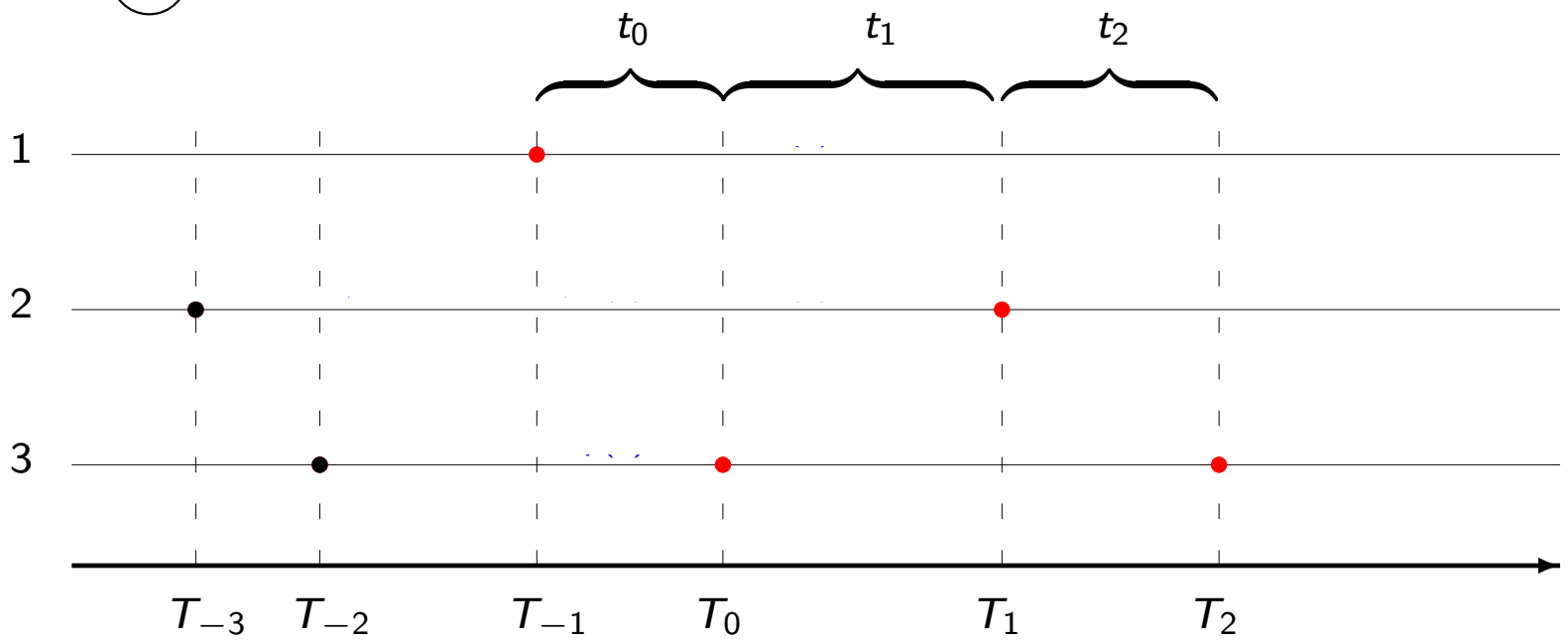
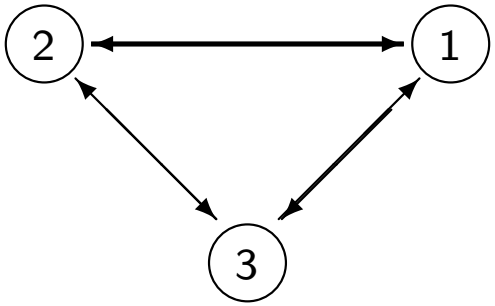


$$Y_{-1}^2 = 1323$$

$$U_2 = (3, 1, 0)$$



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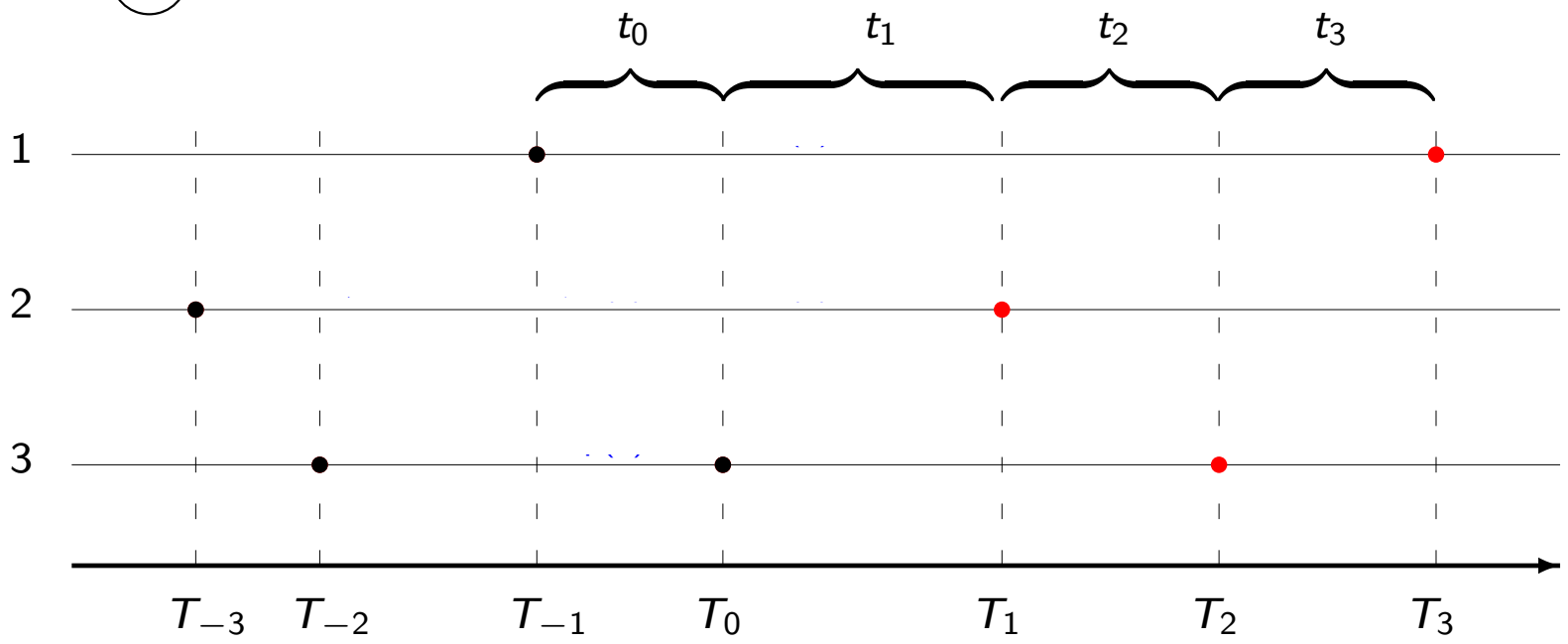

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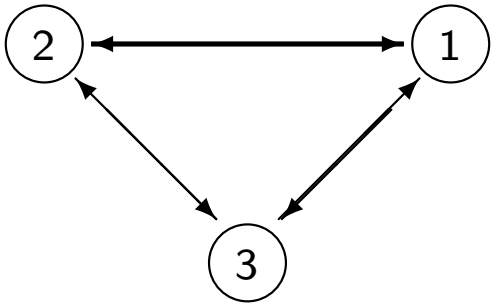

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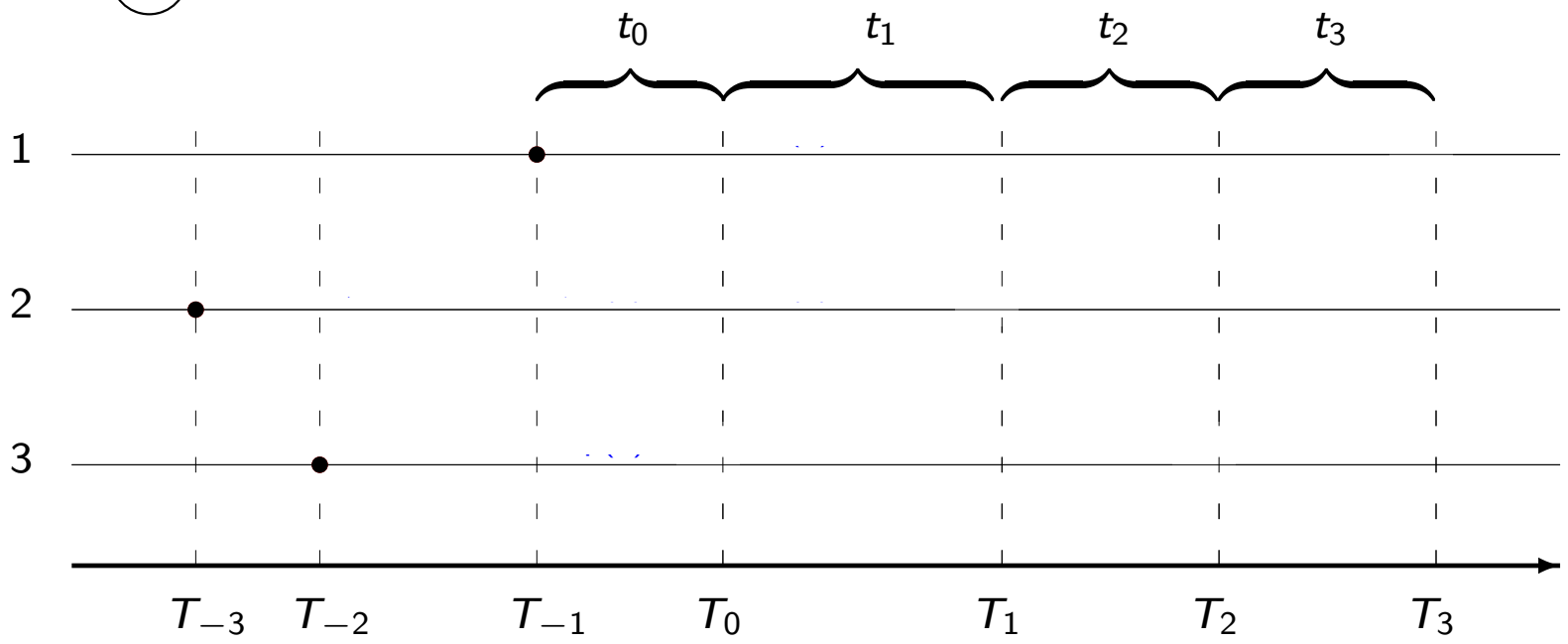

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Example with 4 neurons

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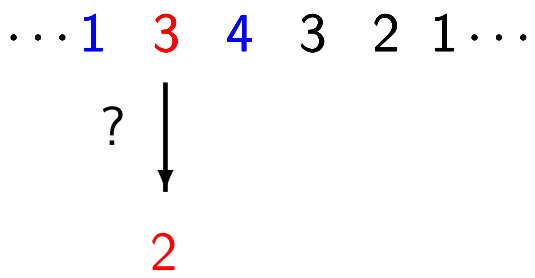

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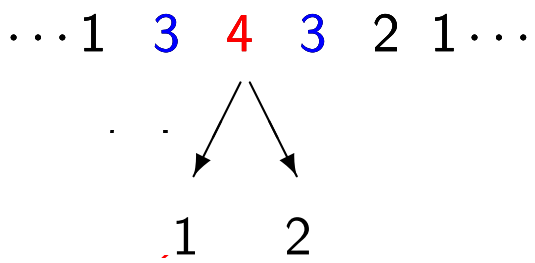

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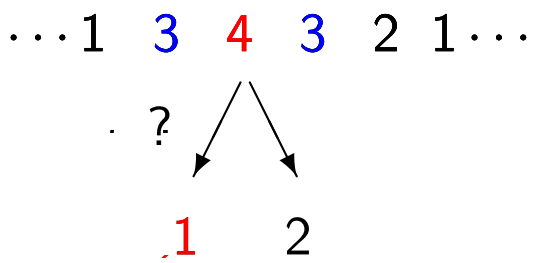

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We estimate the probability for each spike to originate from each neuron.

For instance, if we discard the first V_i iterations, the probability of the 20th spike to have been generated by the third neuron is:

$$\mathbb{P}(Y_{20} = 3|\mathbf{D}) \approx \frac{1}{V_f - V_i} \sum_{v=V_i}^{V_f} 1_{\{Y_{20}^{(v)}=3\}}$$

where V_f is the total of iterations and $\mathbf{D}$ is a sample of times until next spike.

- A. Galves and E. Löcherbach. Infinite systems of interacting chains with memory of variable length - a stochastic model for biological neural nets. Journal of Statistical Physics, 151(5):896-921, 2013.

- Pouzat C, Delescluse M, Viot P, Diebolt J. Improved spike-sorting by modeling firing statistics and burst-dependent spike amplitude attenuation: a Markov chain Monte Carlo approach. J Neurophysiol, 91:291028, 2004.

The End