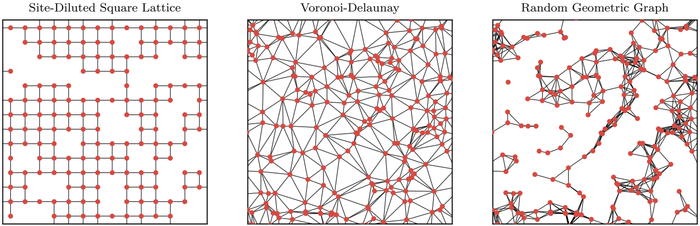

Epidemic Spreading on Random Lattices

Non-Equilibrium Phase Transitions vs Quenched Disorder

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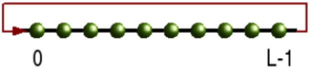
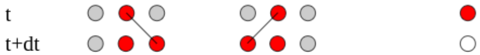
Contact Process

Let's build a 1D toy model for **epidemic spreading**:

- Periodic chain



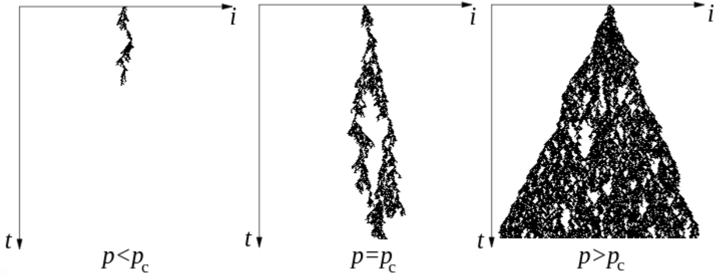
- Each site occupied by one individual, which is **infected** or **healthy**
- Two possible interactions:
  - Infection of a neighbour
  - Spontaneous self-recovery



- Parameter: Infection probability $p \in [0, 1]$
- Can be implement by standard Monte-Carlo techniques
- Not solved analytically so far, even in 1D

Phase Transition

Infection probability controls the evolution of the system



Critical point p_c separates **two phases**:

- $p < p_c$: Infection dies out (absorbing state)
- $p > p_c$: Infection spreads the whole system (active phase)
- $p = p_c$: Transition between survival and extinction

Exactly at the critical point various observables show power-law behaviour, e.g. number of infected particles scales as $N(t) \sim t^{\theta}$. θ is called a **critical exponent**.

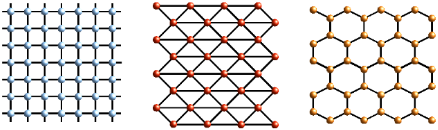
Universality

Values of critical exponents are **irrespective of any microscopic details**, i.e. we can

- Add more interactions

diffusion *coagulation* *annihilation*

- In multi-D: Change the lattice geometry



This changes only the location of the critical point. The exponents remain the same!

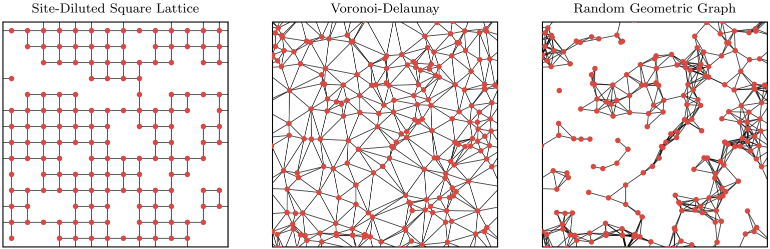
$\rightarrow$ **Universality class** (here: *Directed Percolation*)

The directed percolation universality class comprises various different phenomena, e.g. transport in porous media, forest fires, certain chemical reactions, transition from laminar flow to turbulence or evolutionary dynamics

Disordered Lattices

Spatial disorder models, e.g.

- Geographical inhomogeneities (in epidemics)
- Defects in solids, amorphous materials (in solid state physics)



Current research questions:
Which universality classes are stable against which kinds of disorder? Is the phase transition changed? What are the criteria?

HPC aspects:

- **Long** simulation times (up to 10^8 time steps) and **large** systems (up to 12.000^2 sites)
- Additionally: Average over **many** disorder realizations