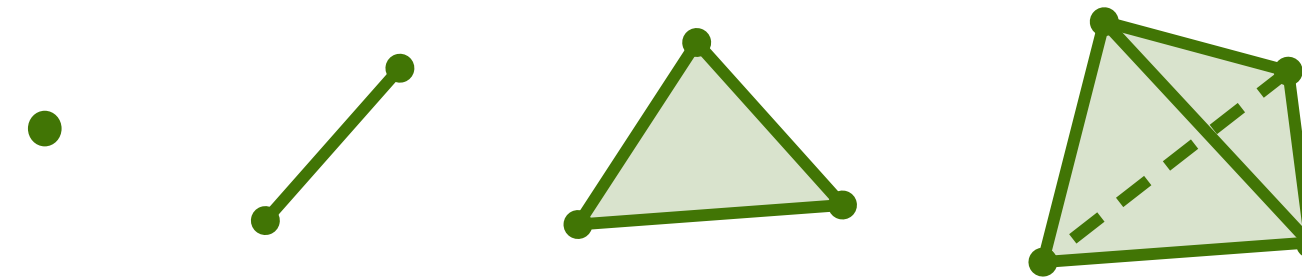
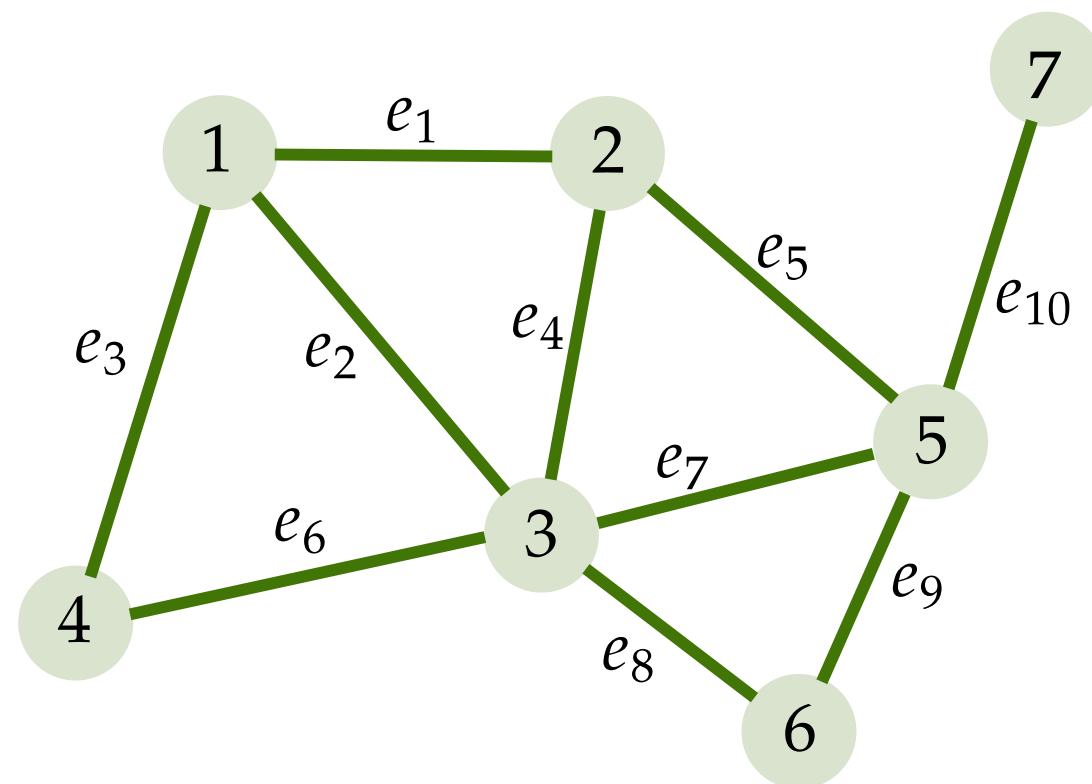


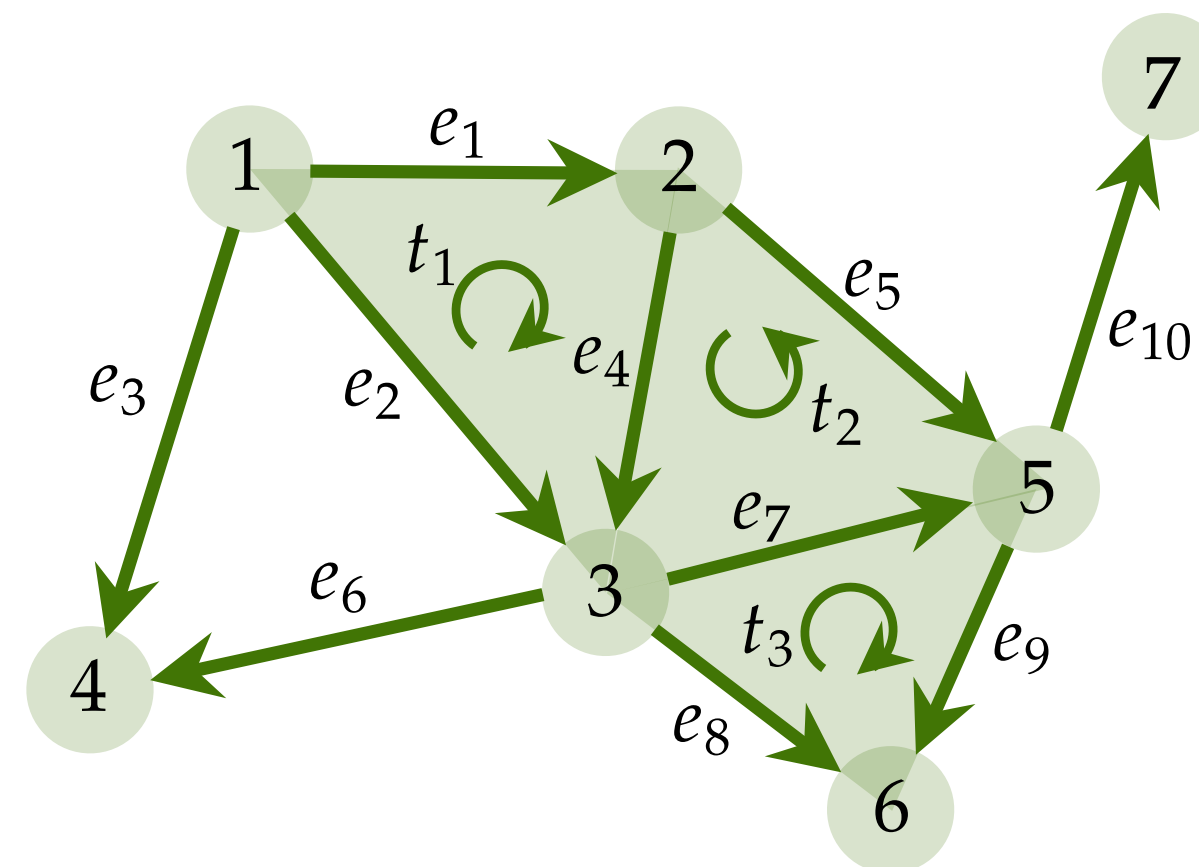
Graphs vs Simplicial 2-Complexes



0-, 1-, 2-, 3-simplices



Graph = Simplicial 1-complex



Simplicial 2-complex

- Oriented simplices (equivalence class of permutations)

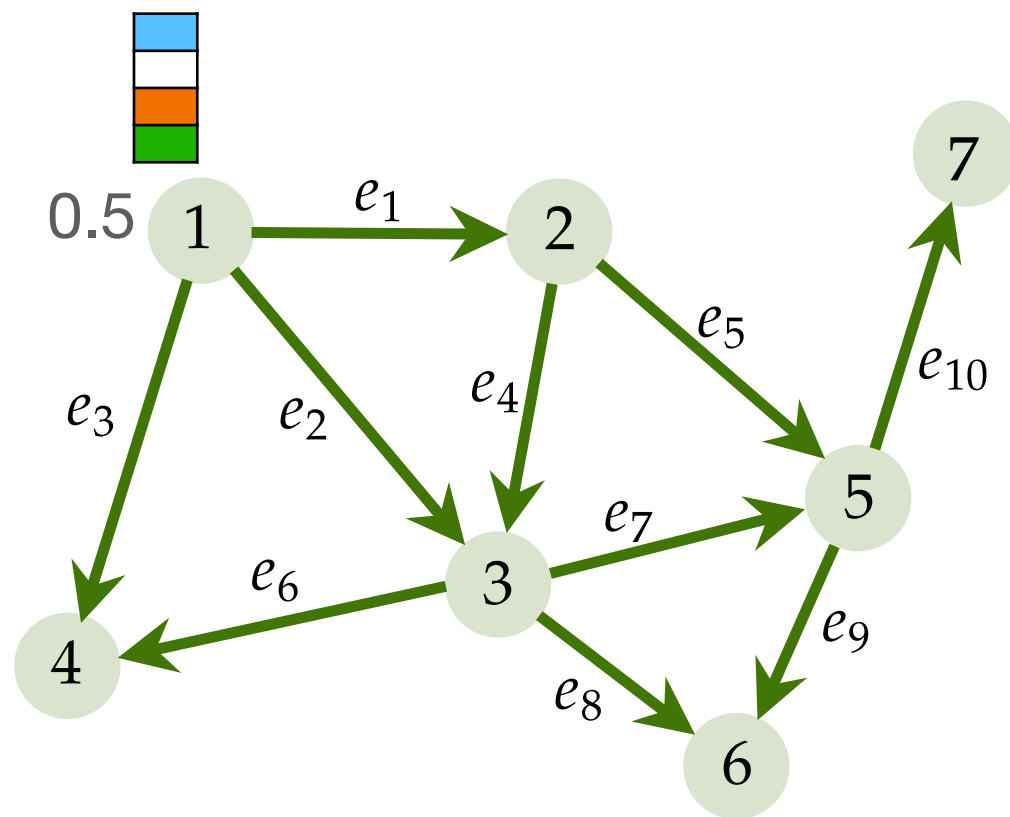
Where are SCs used?

- Network analysis
- Topological data analysis
- Topological signal processing
- Topological deep learning
- Numerical methods
- Computer graphics
- ...

- To model Higher-order network structure
- To support Higher-order signals

Functions on simplices

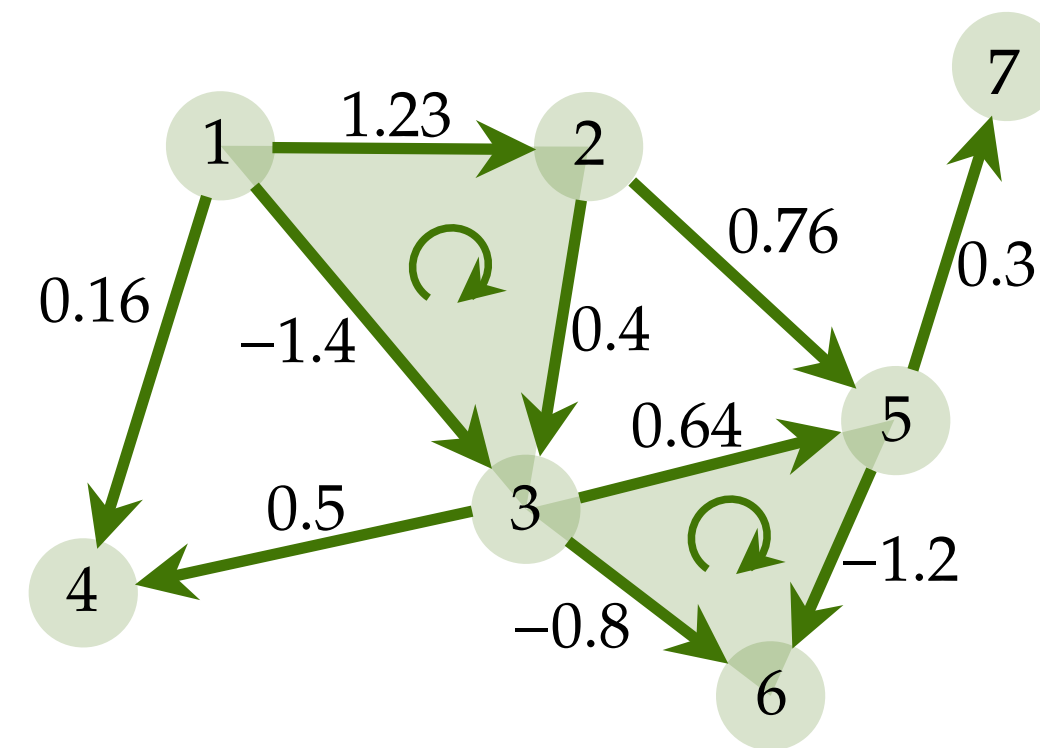
Signals on nodes, edges, triangles, ...



Node function

$$f_0 : V \rightarrow \mathbb{R}$$

$$\mathbf{f}_0 = (f_0(1), \dots, f_0(N_0))^T$$



Edge function

$$f_1 : E \rightarrow \mathbb{R}$$

$$\mathbf{f}_1 = (f_1(e_1), \dots, f_1(e_{N_1}))^T$$

- Alternating property
- Magnitude and sign

Triangle function

$$f_2 : T \rightarrow \mathbb{R}$$

0-, 1-, 2-cochains in topology

- Flow-type data (natural)
 - Physical world: traffic flow, water flow, information flow...
 - Forex: exchange rates
 - Game theory (Candogan et al. 2011)
 - Ranking data (Jiang et al. 2011)
 - Edge-based vector field discretisation (computer graphics)
 - ...
- Representation learning
 - High-dim edge features