

Introducing features of agency into computational models of infectious disease

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Outline

- 1 Introduction to Computational Disease Modelling
 - Graph Theory
 - Games on Graphs
- 2 Extending existing graph models to account for agency
 - Attributes of Agency
 - Protection Rating Allocation and Defence Strategies
- 3 Conclusion

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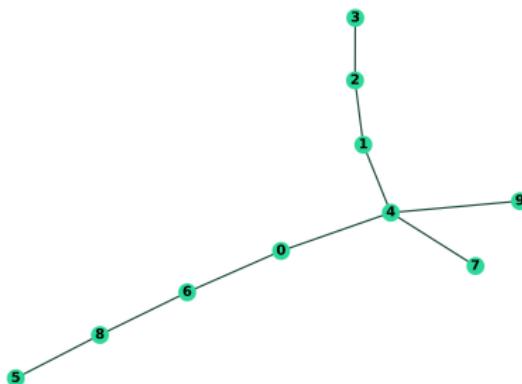
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- A set of objects where some pairs are related.
- Objects are called *vertices* or *nodes*
- Relations between objects are called *edges*.

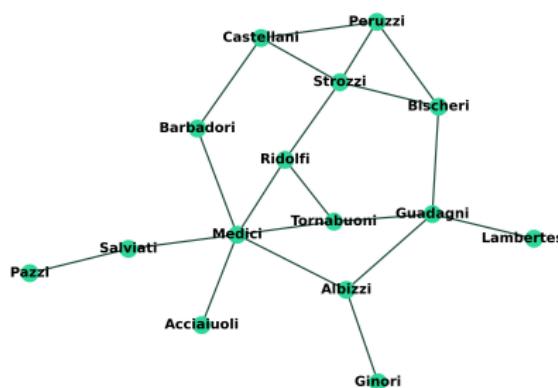
Examples of Graphs



Example: Tree

A tree is a special type of graph where *any two vertices are connected by exactly one path.*

Examples of Graphs



Example: Florentine Families Graph

Depicts the marital alliances between Renaissance Florentine families

Using Graphs to Model Disease Spread

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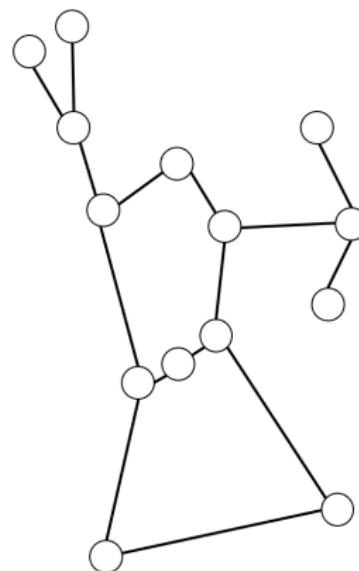
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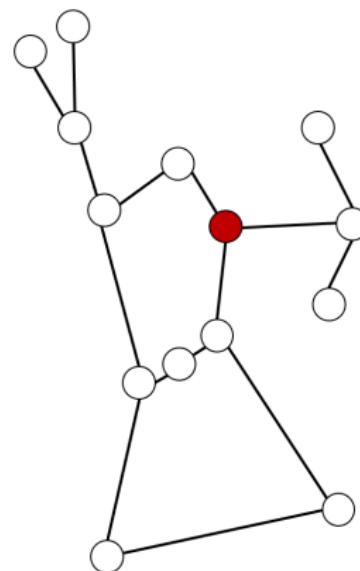
- At $t = 0$, a fire breaks out at some vertex in the graph.
- Firefighter then ‘protects’ some other vertex.
- Fire spreads to any adjacent vertices neither protected nor burnt.
- Firefighter protects another vertex, the fire spreads again and so on.

Example



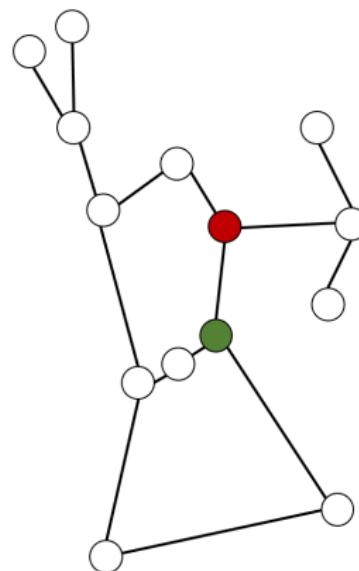
Original Graph

Example

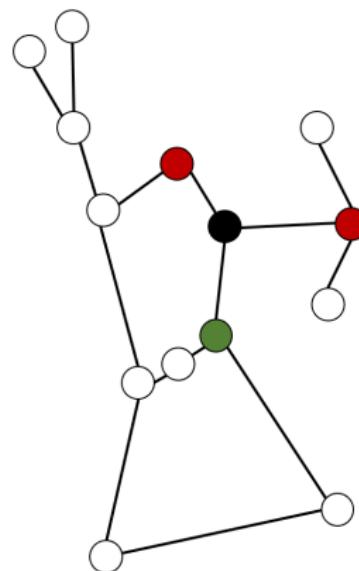


Outbreak

Example

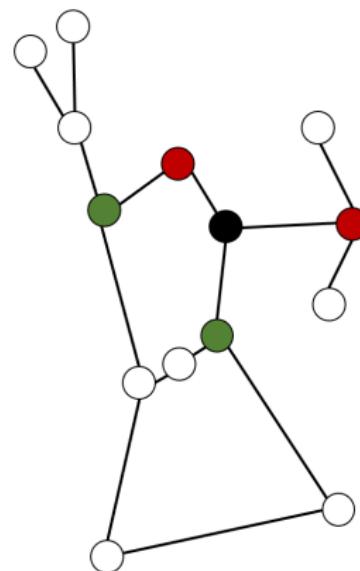


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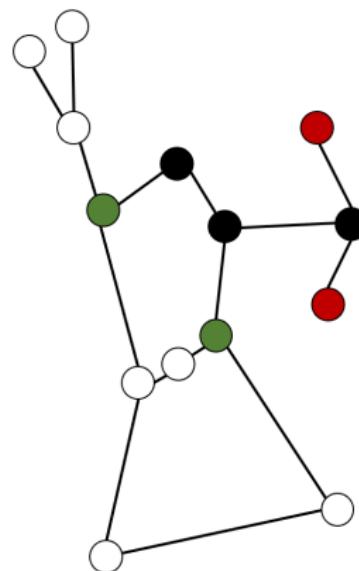
Fire Spreads

Example



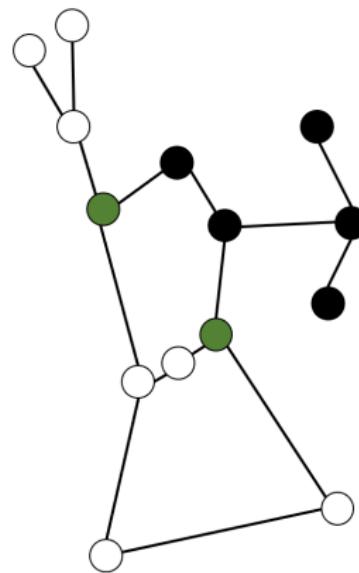
Defence

Example



Fire Spreads

Example



Fire contained

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- Fairly rudimentary model for disease spread but already NP-hard.
- Defence and infection are discrete but epidemic propagation is a stochastic process.
- Only interventions in halting disease spread are *external*, no way for individuals to avoid contraction personally.

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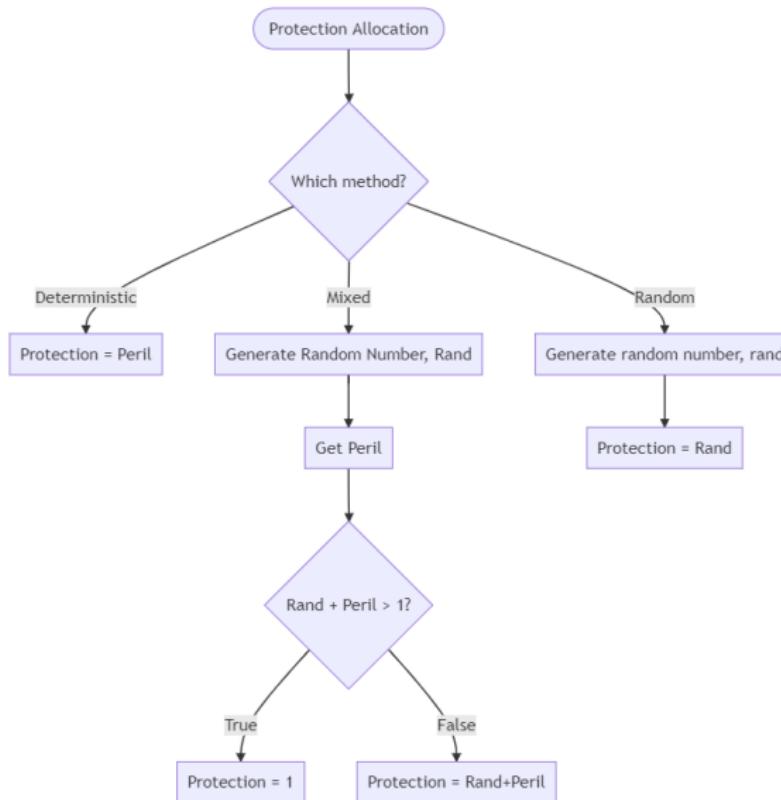
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- Wearing PPE correctly
- Hand hygiene
- Strict physical distancing

Agency in disease modelling

└ Extending existing graph models to account for agency

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Defence Strategies

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In usual formulation, general rule of thumb: *for sparse graphs, defend based on proximity to fire (break ties on degree); for dense graphs, defend based on highest degree (break ties on proximity)*.

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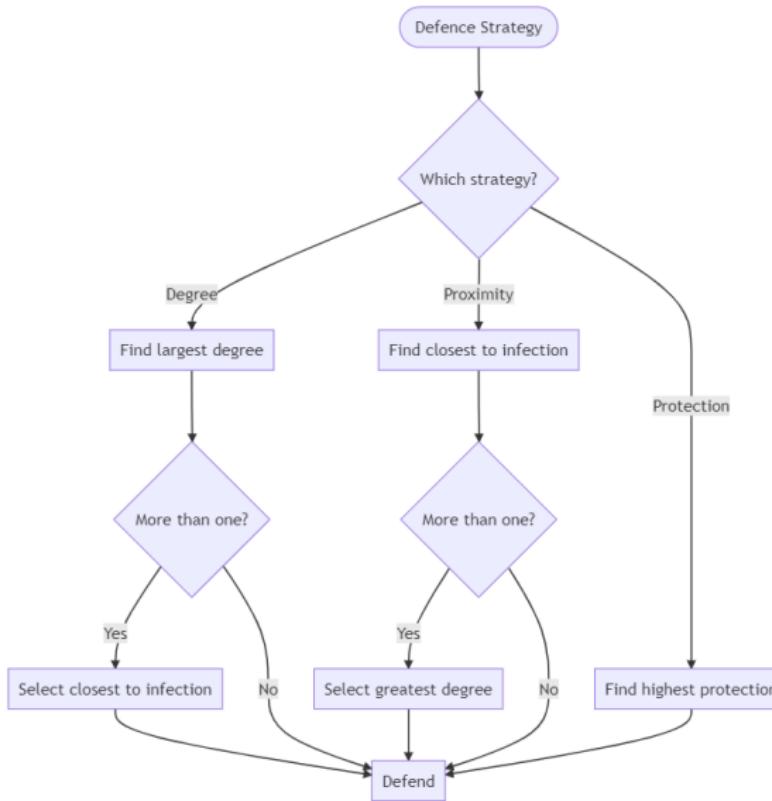
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However, in our adjusted formulation we have more candidates for defence strategies. One such novel strategy is to defend based on highest agent protection rating.

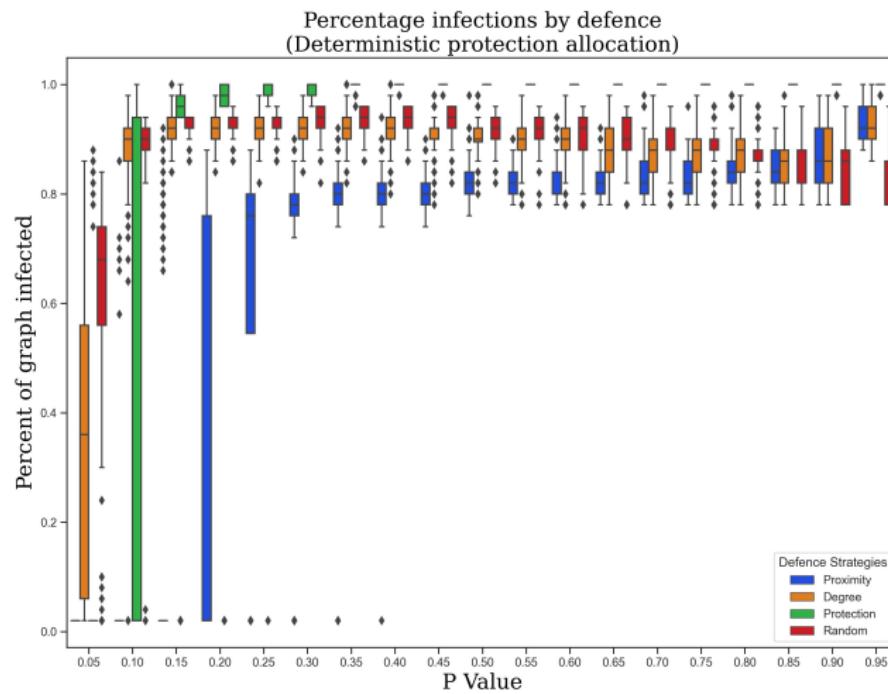
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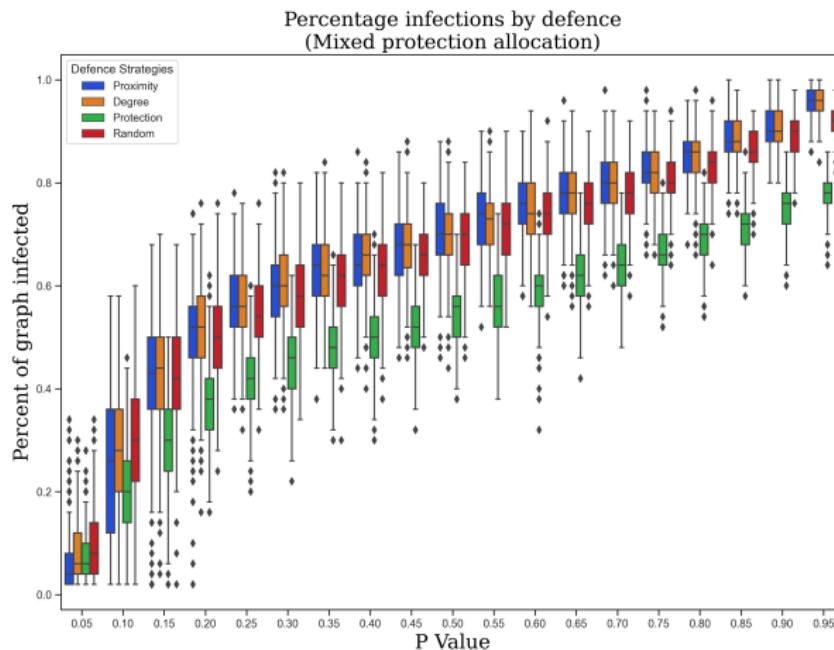
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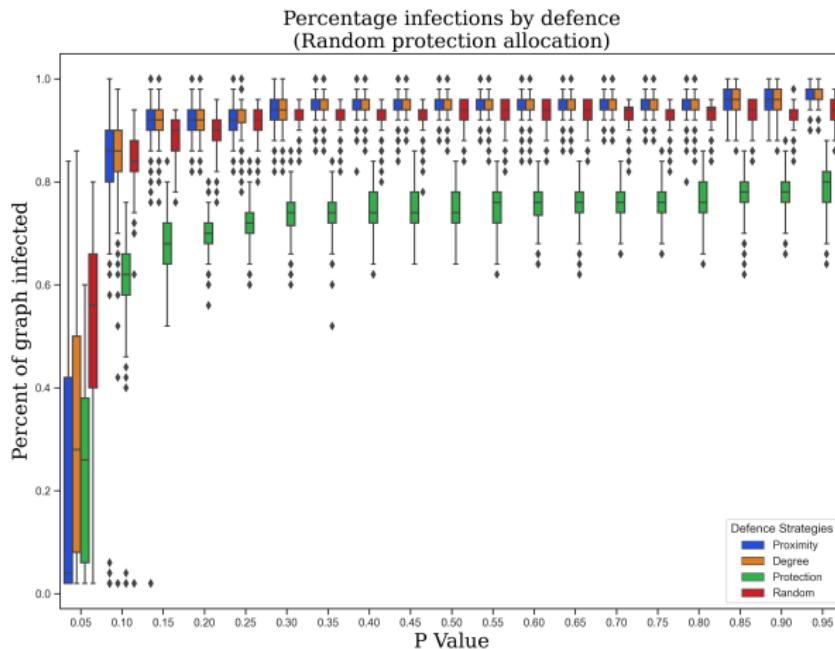
Deterministic Protection



Mixed Protection



Random Protection



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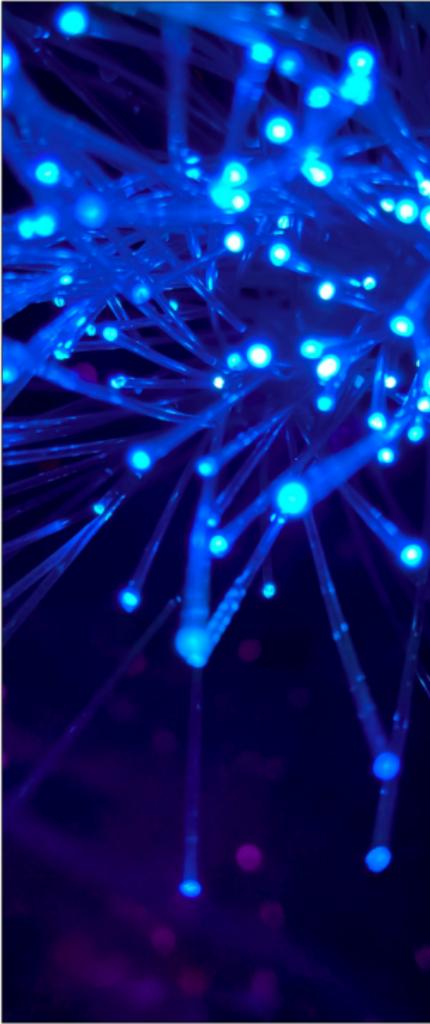
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- Some fundamentals of Graph Theory
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- Failings of this approach
- How agency can address these issues
- What agency-based modelling looks like



Thanks for listening!

Any questions?