Using graph theory to investigate the role of expertise on infrastructure evolution: A case study examining the game Factorio

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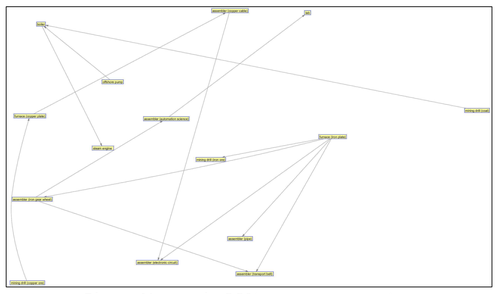
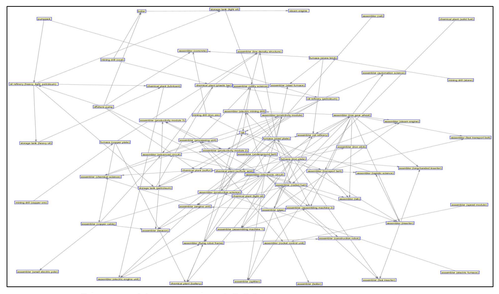
Introduction

- Need for design guidance when making infrastructure decisions
- Two roadblocks:
  - Proprietary/unavailable real-world network performance data
  - Focus on an infrastructure network at a single point in time, instead of covering whole evolution

Factorio

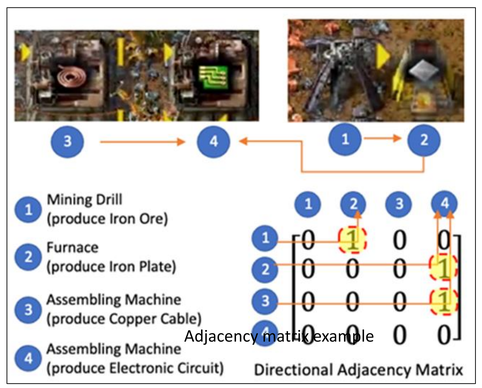
- Utilized different source of network data: the video game Factorio.
- Factorio is a manufacturing simulator
- Primary goal to build/launch a rocket
- Players create factories with evolving networks


Player Network: 20% game progression


Player Network: 100% game progression

Ecological Network Analysis (ENA)

- Subset of graph theory
- Allows researches to represent networks as adjacency matrixes
- ENA enables calculations of different characteristics of the matrix to produce quantifiable metrics



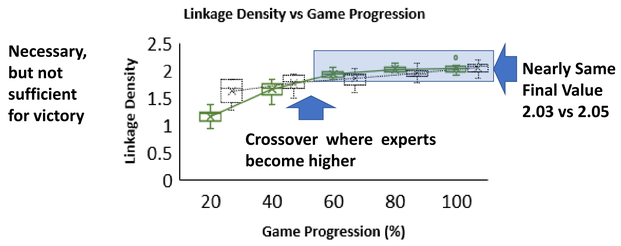
Adjacency matrix example

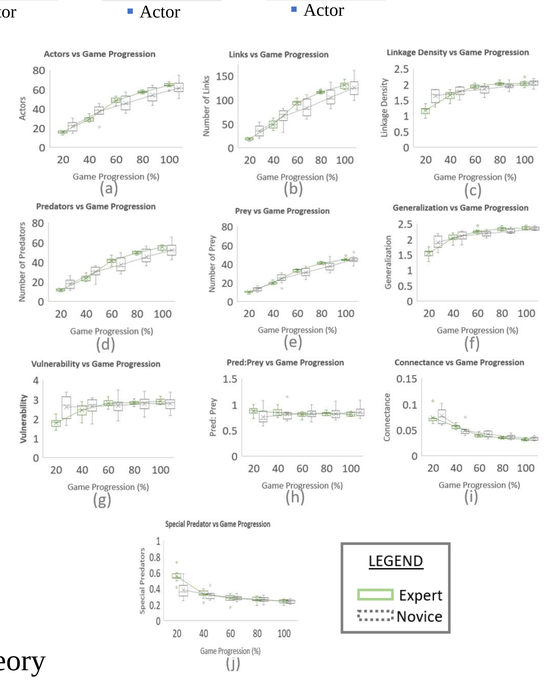
Methods

- Utilized publicly available recordings of 20 speed runners (10 experts and 10 novices)
- 5 snapshots at 20% intervals of player's total time (+/-1%)
- Analysed 10 ENA metrics for both experts and novices vs game progression
  - Actors (A)
  - Links (L)
  - Link Density (LD)
  - Prey (Producers)
  - Predators (Consumers)
  - Generalization (G)
  - Vulnerability (V)
  - Ratio between Predators and Prey (Pred:Prey)
  - Connectance (C)
  - Special Predator (SP)

Findings

- Performance gap of 6 hours average for same final goal
- Expert network evolution 5 times more efficient
- Differences in early network designs between experts and novices





Contributions

- Produced analysis of how ten different graph theory metrics evolve when comparing experts and novices
- Set of time-series data for twenty cases

Future work

- Additional testing for similar trends in other systems
- More data collection with Factorio, involving additional ENA metrics

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