# Provchastic: Understanding and predicting game events using provenance

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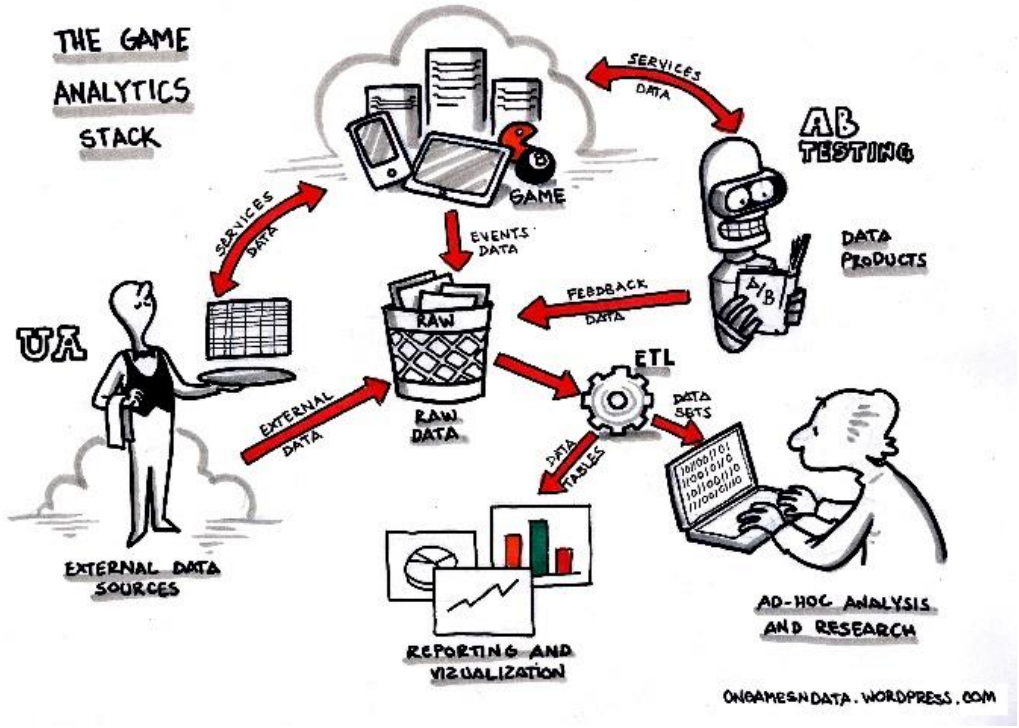
# Game Analytics

- Game analytics became an emerging field
  - Important for business intelligence and provides a wealth of information
- Support the decision-making process for game development
  - Operational, tactical, and strategic levels



# Predictive Analytics

- Predictive analytics is one of the many aspects of game analytics
  - Generates predictive models derived from datasets
- Many researches available
  - RTS prediction with Markov Chains (Dereszynski et al, 2011)
  - Discover combat strategies of winning teams in MOBA (Yang et al., 2014)
  - Predict match results in Dota2 (Schubert et al., 2016)
  - Forecast changes in the hero's health in Dota2 (Cleghern, Zach, et al., 2017)
- They use game metrics over the course of the game session for predictions
  - What about contextual information?

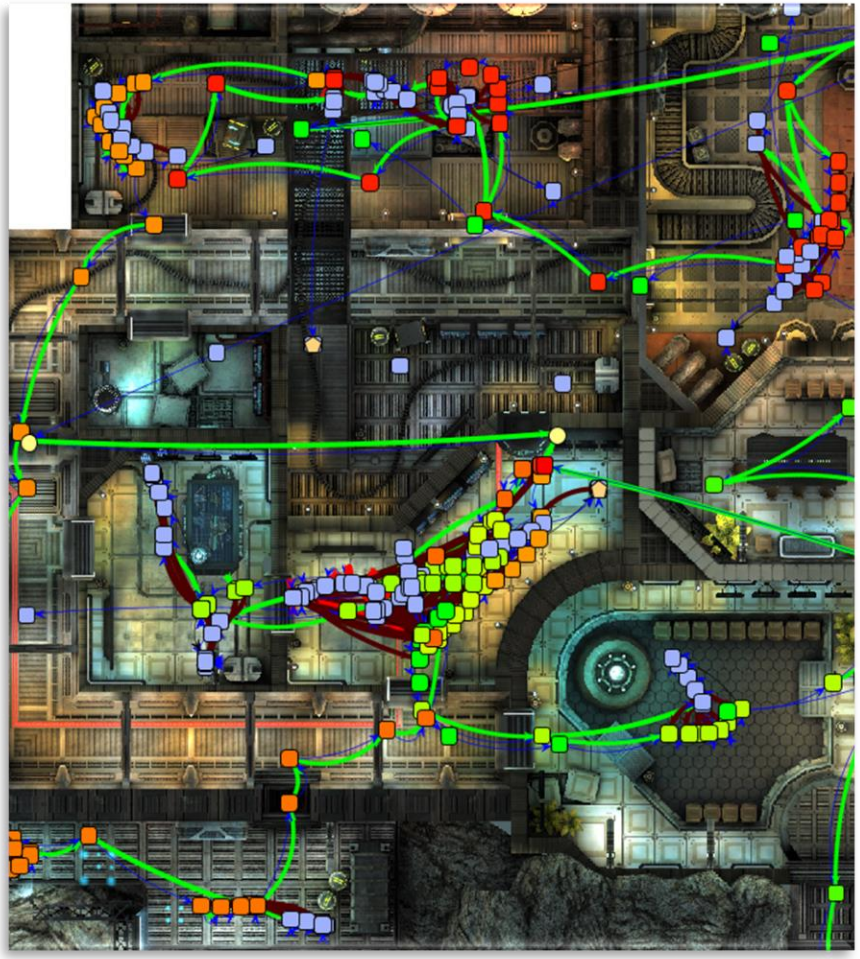
# Goals

- Create a stochastic approach for game analytics
  - Markov chains using provenance data
  - Determines the sequence of possible events
  - Takes advantage of the graph nature of the provenance data
  - Can be used for both predicting future events and understanding the causes for the events

# Provenance in Games

- Track game session data

- Provenance graph
  - Relations between actions, agents, and entities
  - Causal relationships

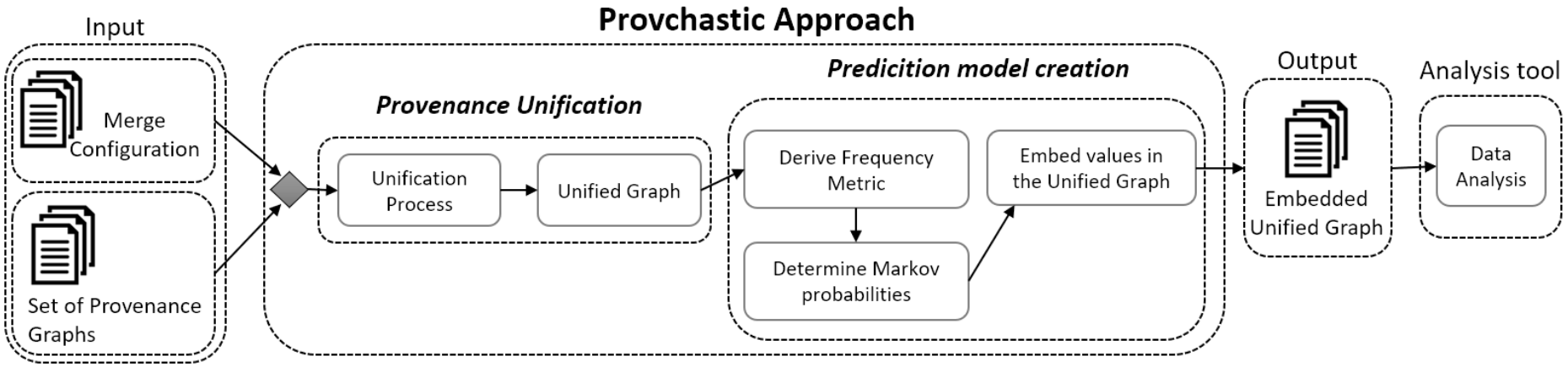


PinGU – Provenance in Games
*(Kohwalter et al., 2017)*
http://gems-uff.github.io/ping/

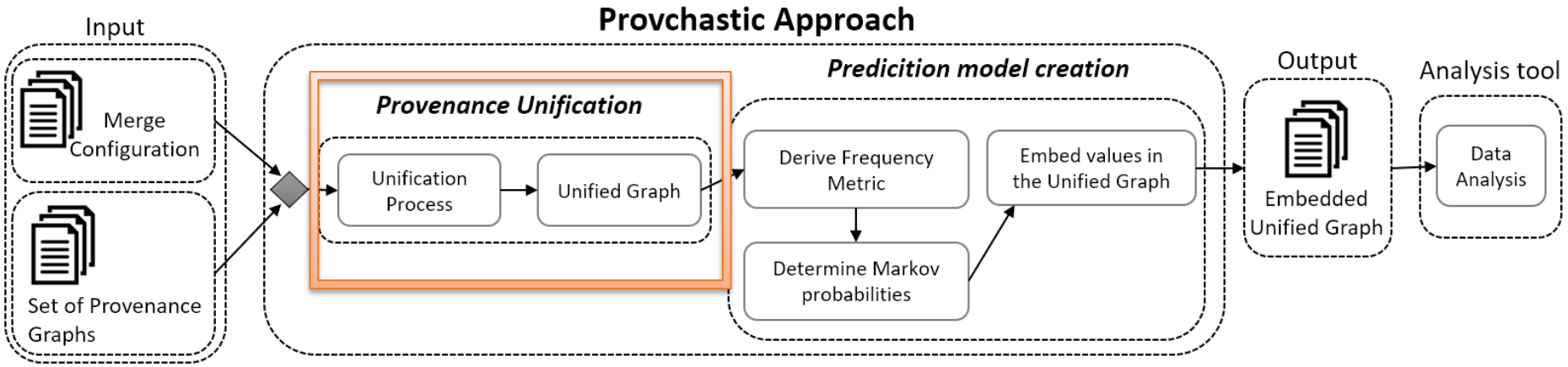
# Provchastic

- **Prov**enance for generating sto**chastic** models
- Uses the commonly known **Markov Chains**
- Stochastic model derived from a set of provenance graphs from captured game sessions
- Combines multiple graphs into a unified provenance graph

# Provchastic architecture

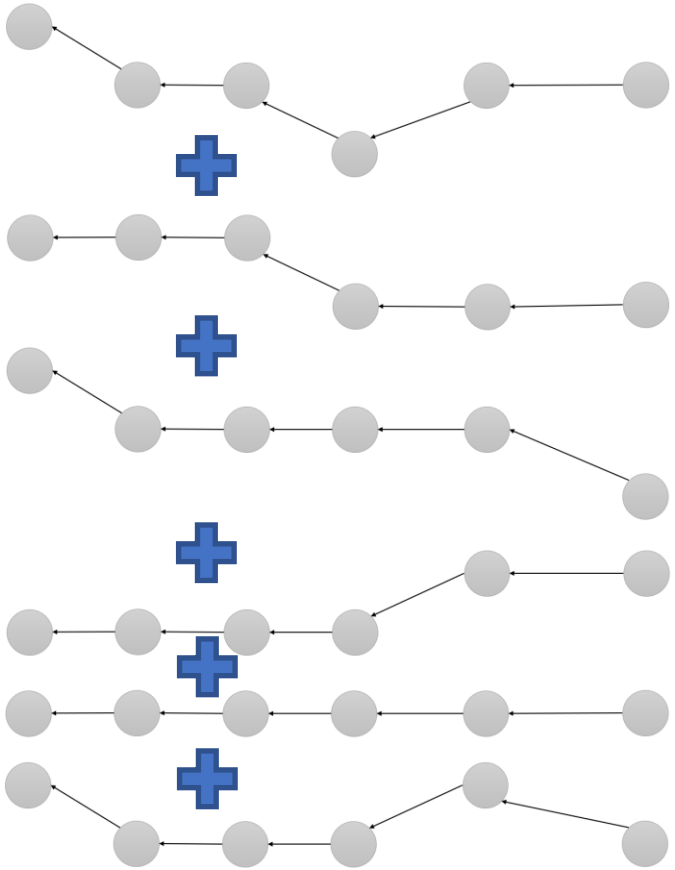


# Provchastic architecture



# Prov Unification

**N** provenance graphs



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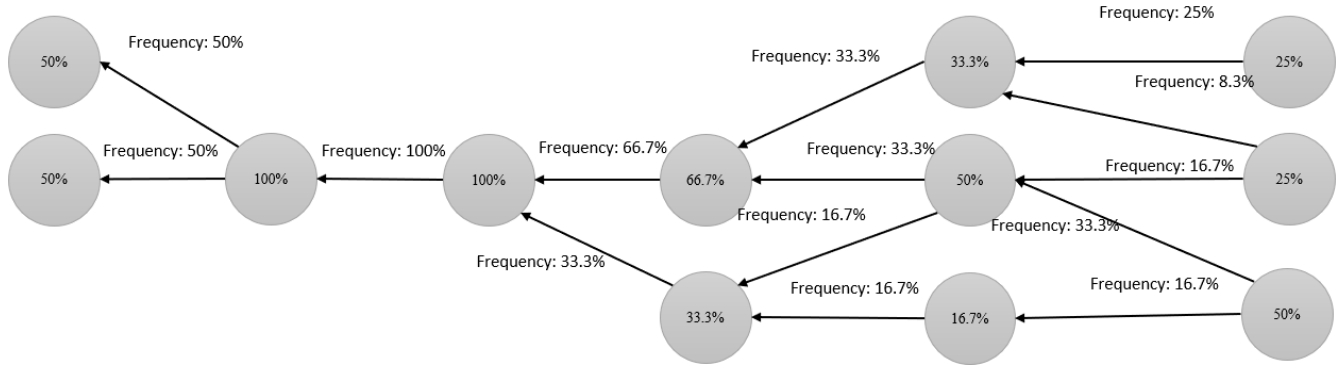
Unified provenance graph



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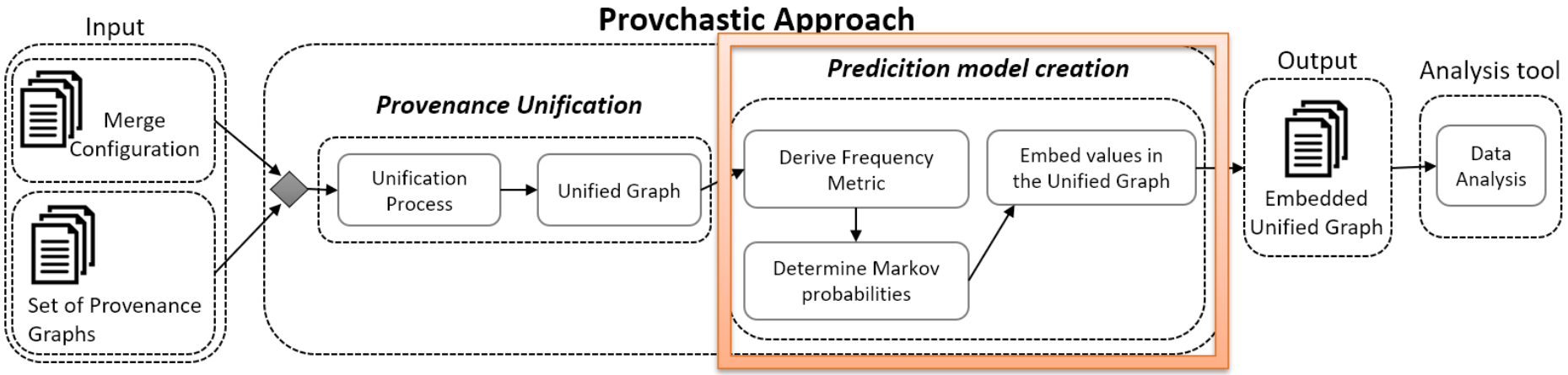
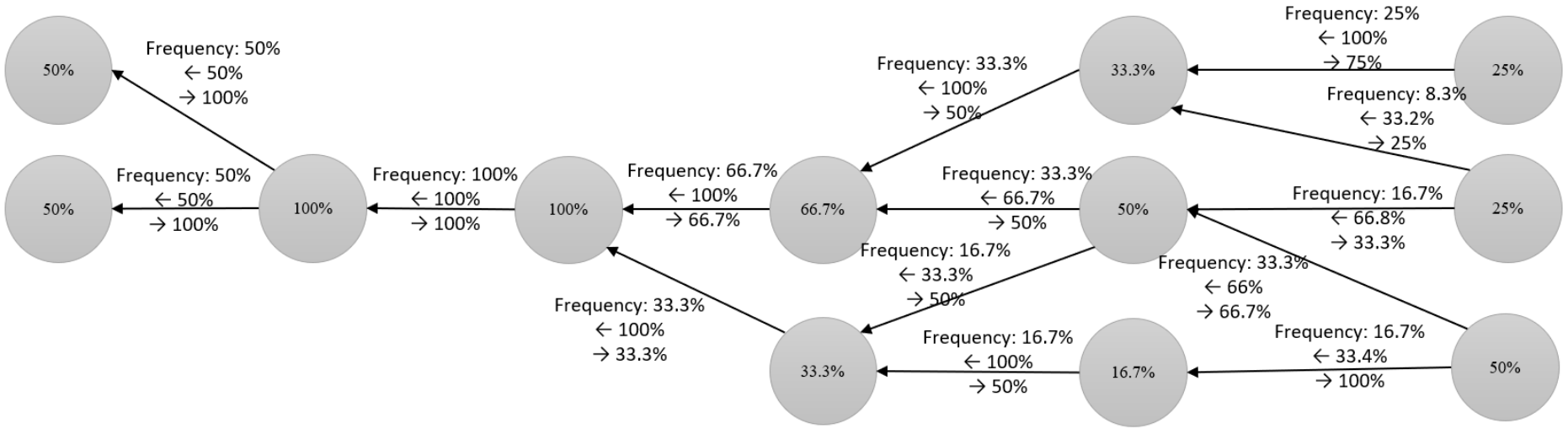


# Stochastic Model Creation

- Uses the **unified provenance graph** to derive statistical information

- The stochastic model generation is composed of two steps:
  1. **Frequency metric**
  2. **Markov probabilities** (future and past)

# Probabilities for *Short Predictions*



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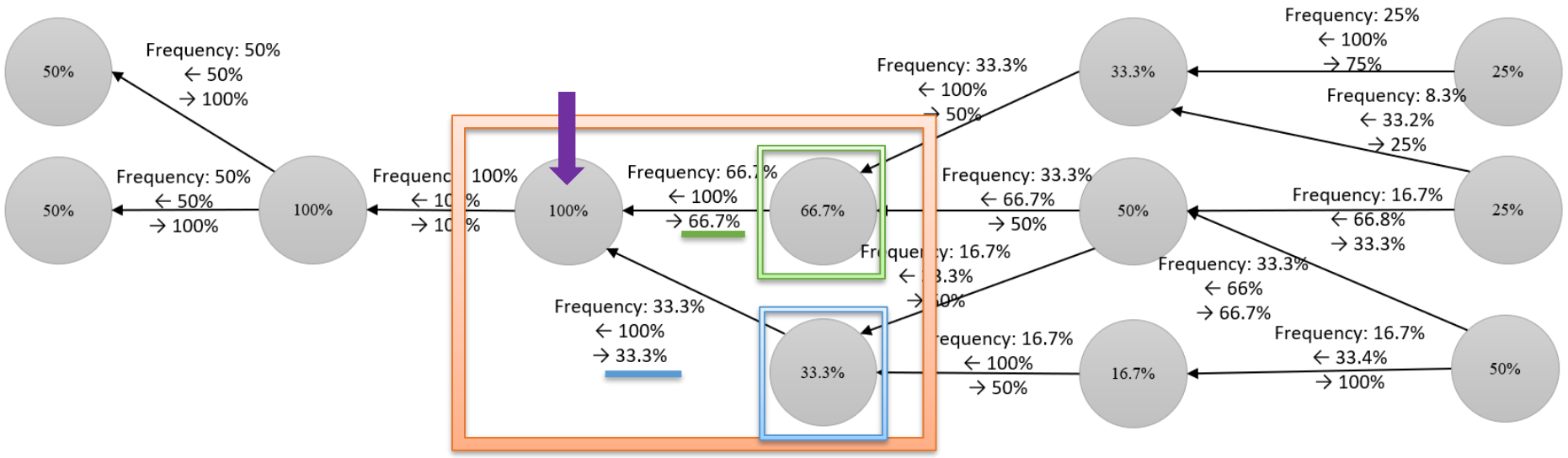

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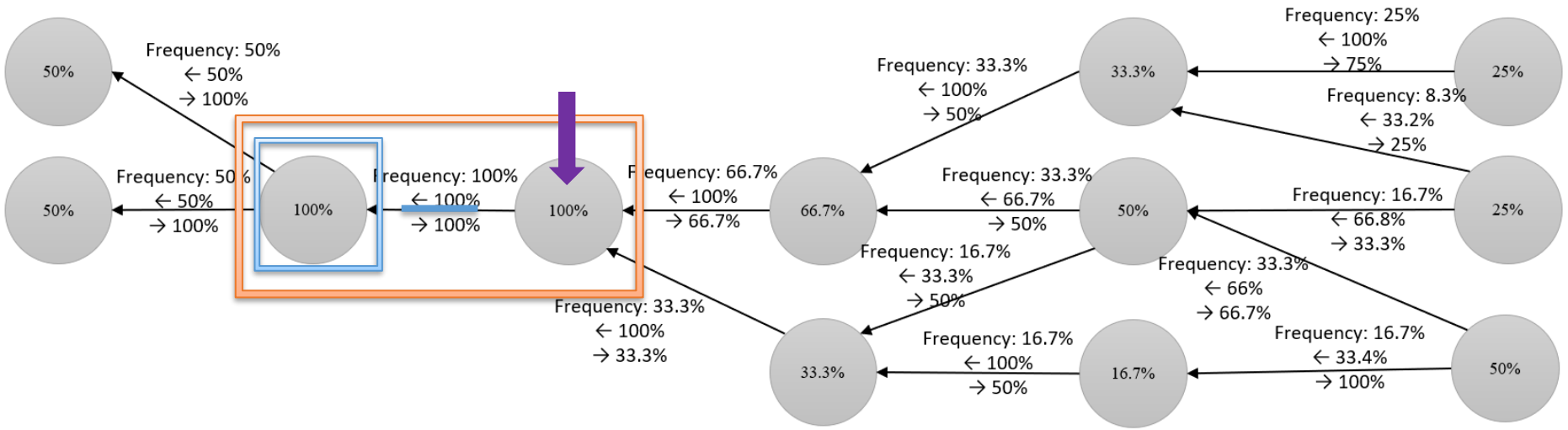
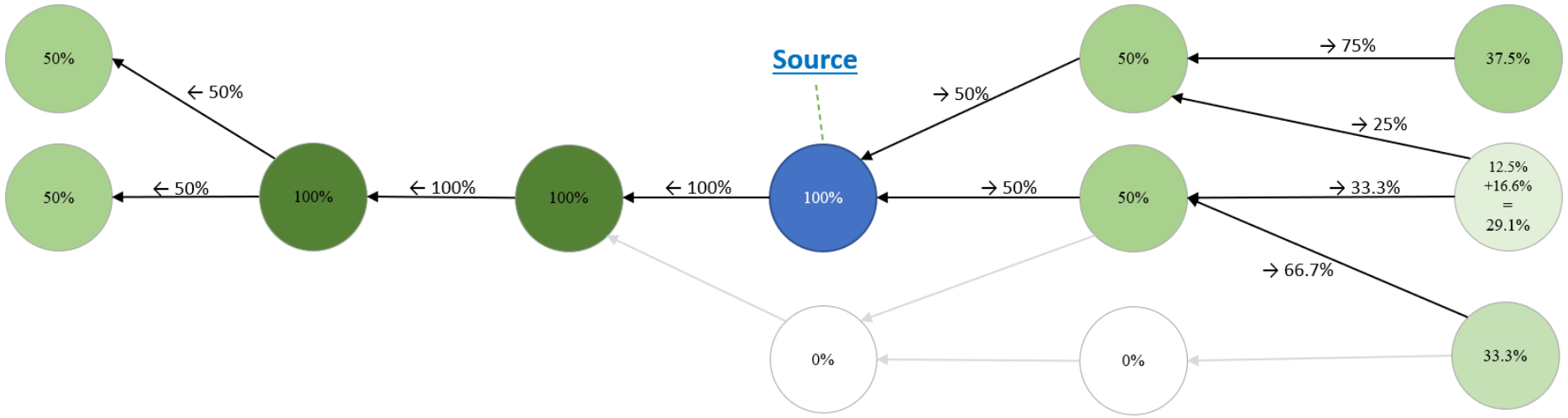
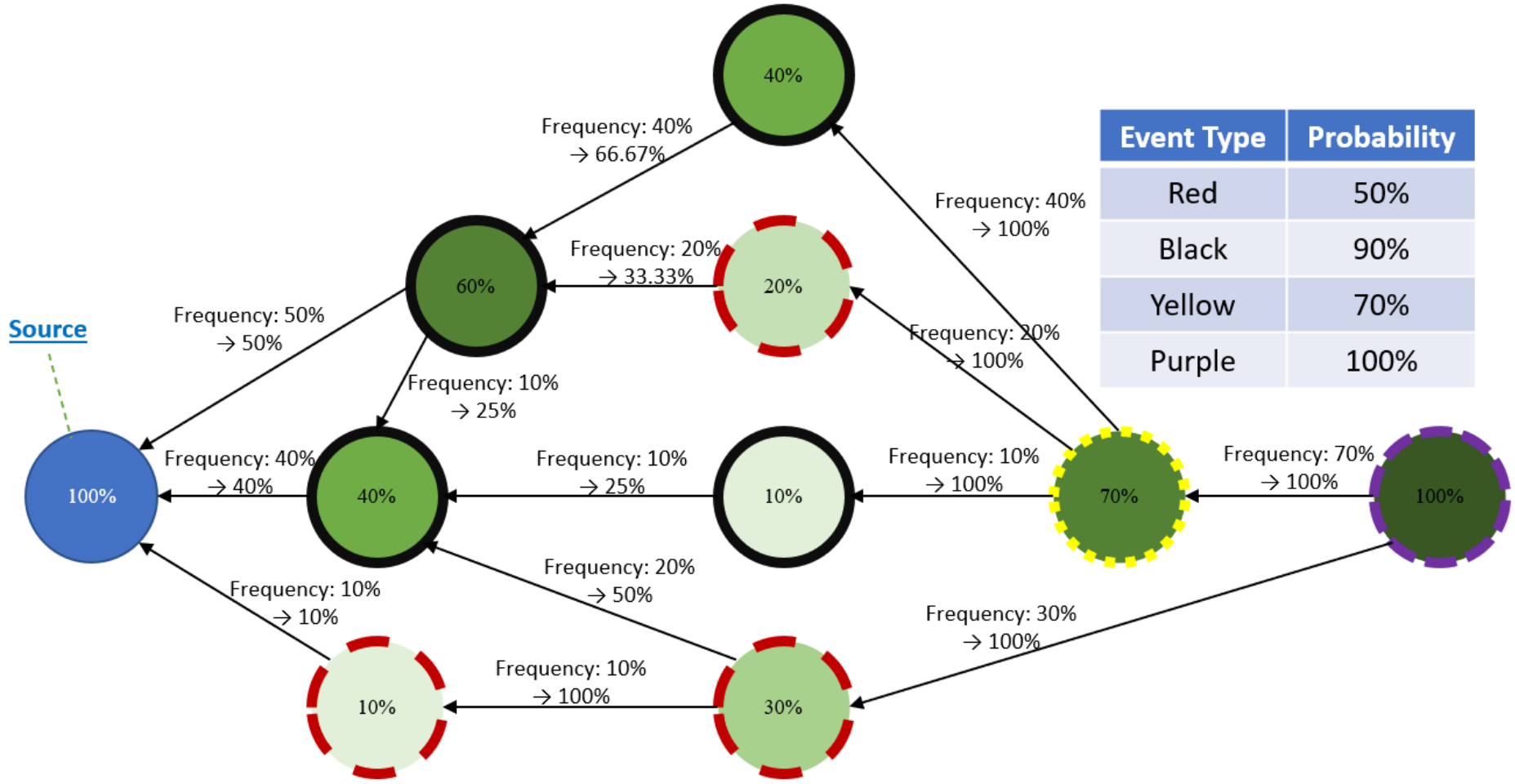


# Probabilities for *Long Predictions*



# Predicting possible events




| Event Type | Probability |
|---|---|
| Red | 50% |
| Black | 90% |
| Yellow | 70% |
| Purple | 100% |

# Case Study

- **Car Tutorial** from Unity asset store
  - Prototype has only one racetrack and is an arcade style racing game
  - **Only player's car** to simulate a practice run
  - **Provenance data** gathering during the session

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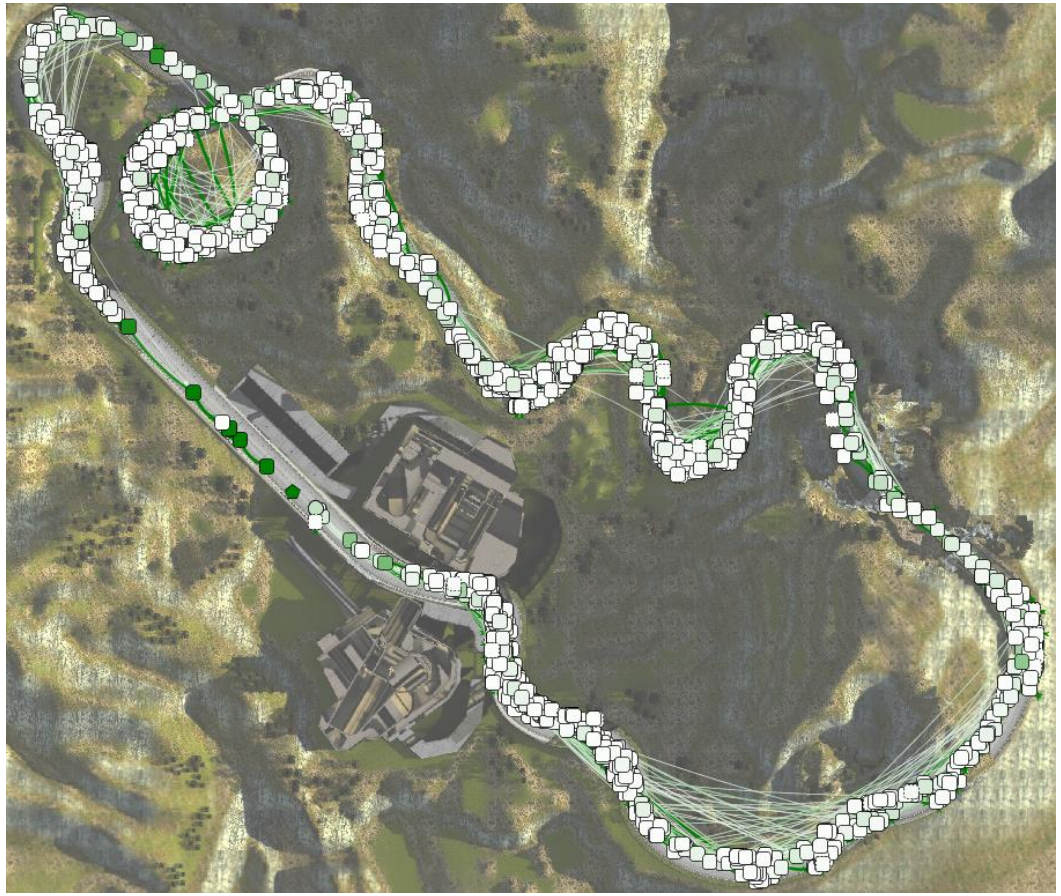
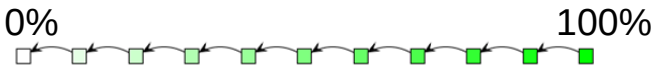
- Stochastic model from **75 provenance graphs**
  - Unified graph composed of **2,302 vertices** and **8,201 edges**
  - Had a **70% reduction for vertices** and **50% for edges**

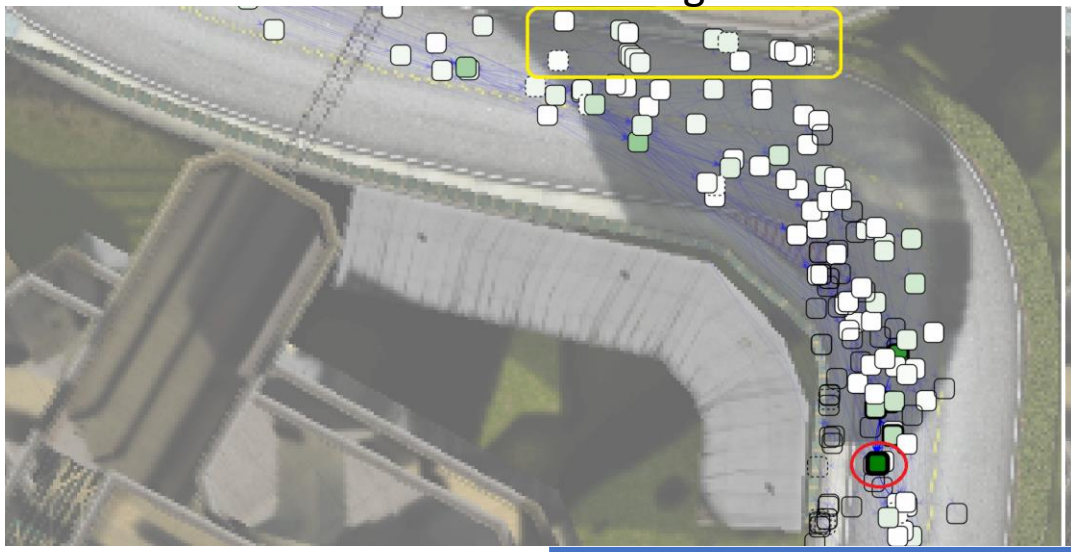


*RQ: Does the use of provenance obtained from multiple game sessions **support predictions** and **understanding** of events for future game sessions?*

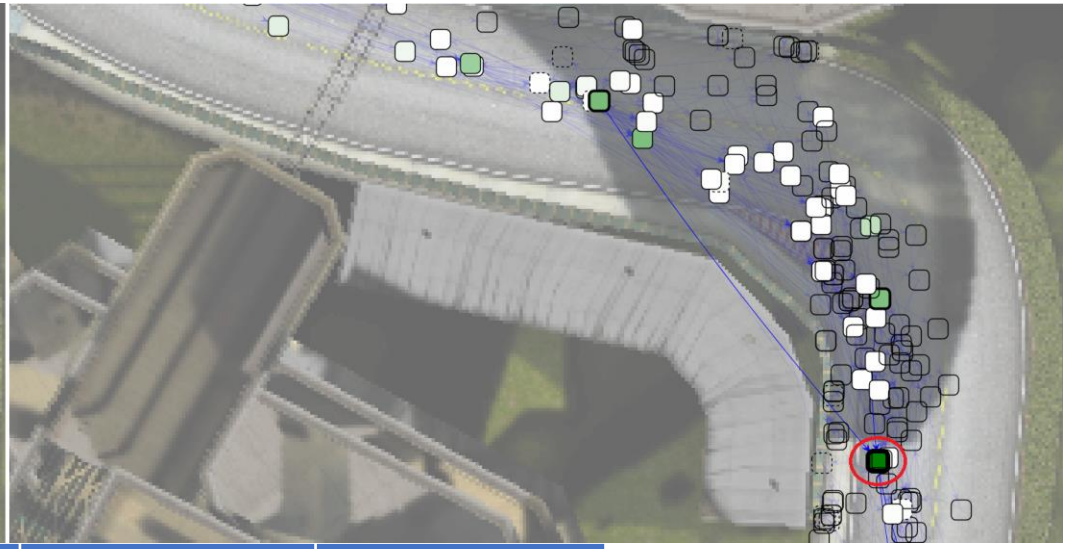
# Contrasting probabilities




Decelerating

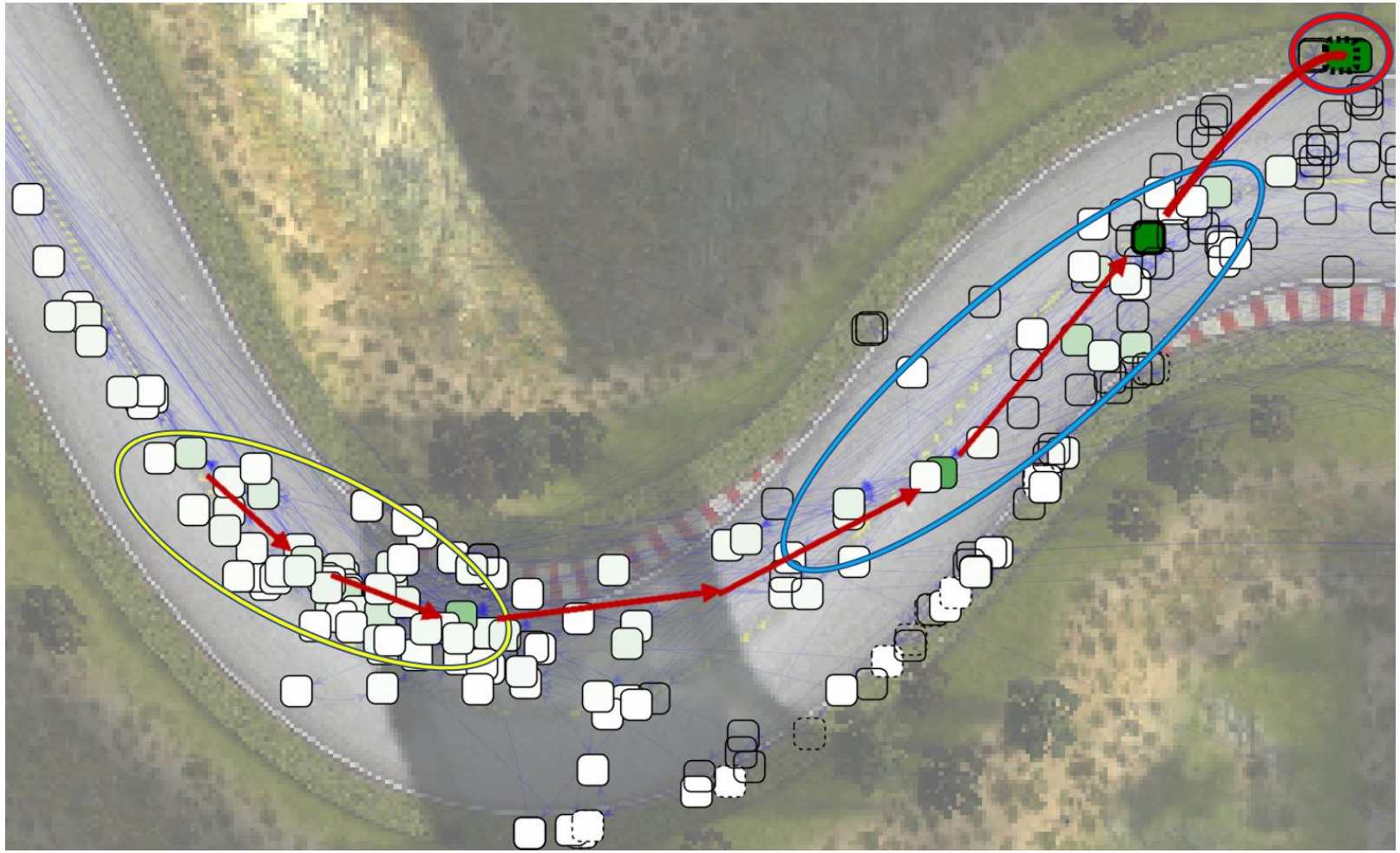


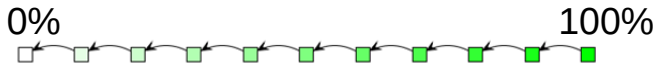
Maintaining Speed



| Event Probability | Decelerating | Maintaining |
|---|---|---|
| Lost Contact w/ Ground | 1% | 17% |
| Crash | 20% | 3% |
| Lost Control | 9% | 3% |
| Scrapped | 17% | 11% |

# Probable cause for the crash





# Research Question

*RQ: Does the use of provenance obtained from multiple game sessions support predictions and understanding of events for future game sessions?*

**Answer**: Provenance graphs may be used to create stochastic models to predict short and long-term outcomes by navigating the graph (future) and to understand how to reach a specific outcome (past).

# Conclusion

- Novel approach for game analytics that creates stochastic models using provenance data
- Demonstrated how to create stochastic models using provenance graphs
- Our stochastic model allows the analyst to find out:
  - Common outcomes for different game states
  - How they were reached
  - Explore multiple game session provenance data at the same time
- Can be used in other domains…
  - Understand experimental trials by determining probable outcomes
  - Devise strategies to minimize the risks of failure
- Limitations:
  - Predictions are only available for previously known traces
  - **Unseen traces**
  - Each query find a similar state in the existing stochastic model

# Future Work

- Finding good patterns in the graphs that reached desirable outcomes
- Detecting bad patterns that should be avoided
- Compare current player performance with previous executions
  - Point out the decisions that improved or degraded her overall performance
- Create a real-time prediction "helper" to aid the player in the decision- making process through projections of the outcome for each decision

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