Toward the Holodeck: Computational Models of Narrative and their Relation to Human Cognition

DOE CSGF 2015 Program Review

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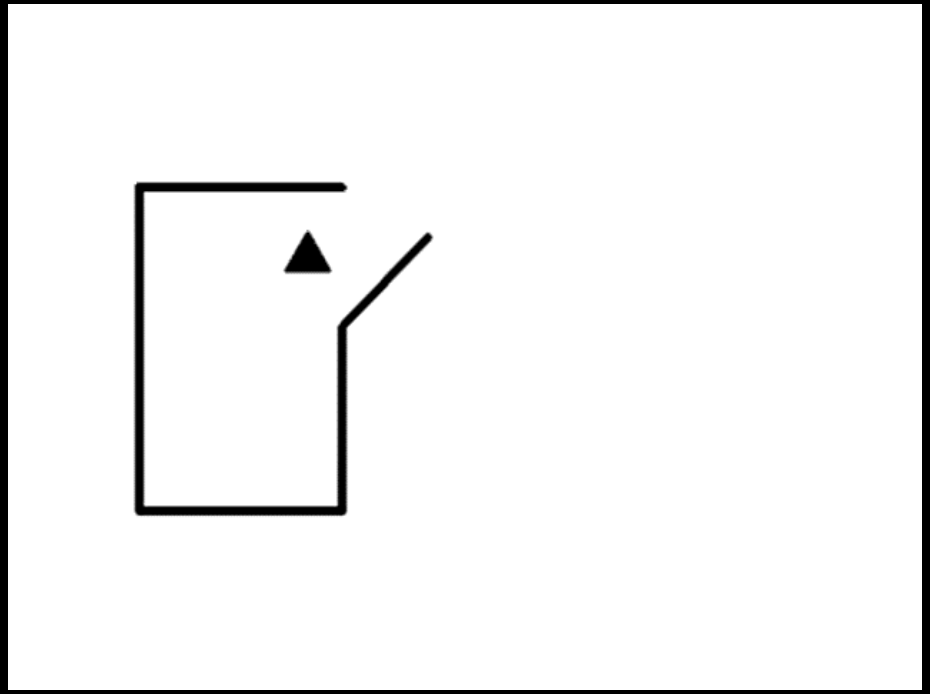
- Chris Forsythe, Kiran Lakkaraju, and Jon Whetzel Sandia Albuquerque
- Krell Institute and the DOE CSGF Program & Fellows!

The Heider-Simmel Experiment



Heider, Fritz and Simmel, Marianne (1944). An Experimental Study of Apparent Behavior. The American Journal of Psychology, 57(2), pp. 243-259.

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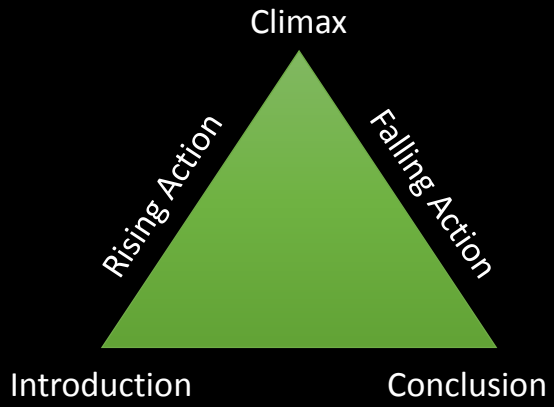
Narrative Intelligence

- We *understand stories* and have *some intuition for what makes a good story*
- Collectively, *comprehension* and *generation* make up what is known as *narrative intelligence* (**NI**)
- Computational modeling is well suited to precisely understand **NI** via artificial intelligence



Simon, H. A. (1996). *The Sciences of the Artificial*. MIT Press. 3rd ed.

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Narrative Intelligence in Two Flavors

Computational Models of Interactive Narratives allow us to understand what is common to both areas

Narrative as a target of interpretation

Narrative as a framework for sense-making

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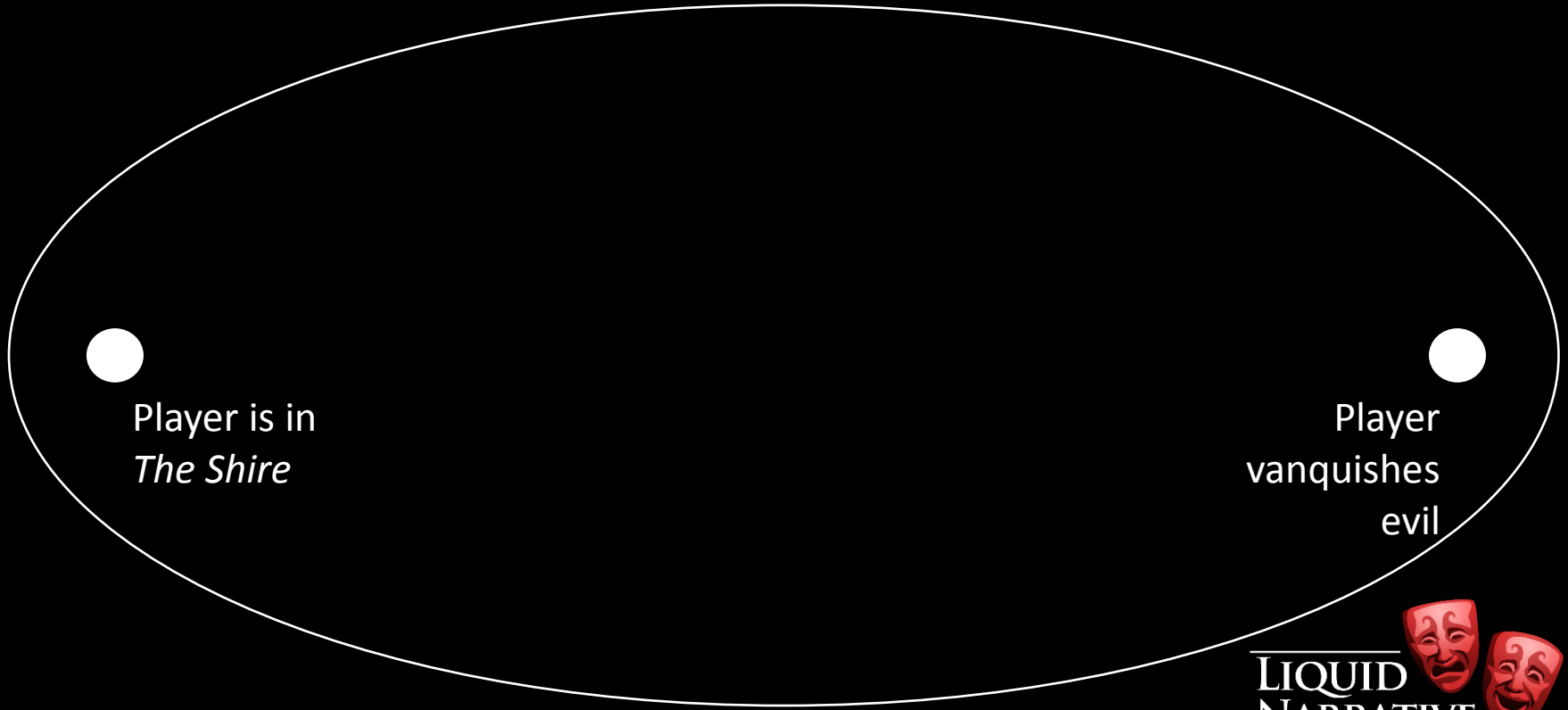
What is an Interactive Narrative?

An interactive experience in which users influence a dramatic storyline through actions by assuming the role of a character in a fictional world

Riedl, M. O., & Bulitko, V. (2012). Interactive narrative: An intelligent systems approach. AI Magazine, 34(1), 67

A Key Interactive Narrative Challenge:



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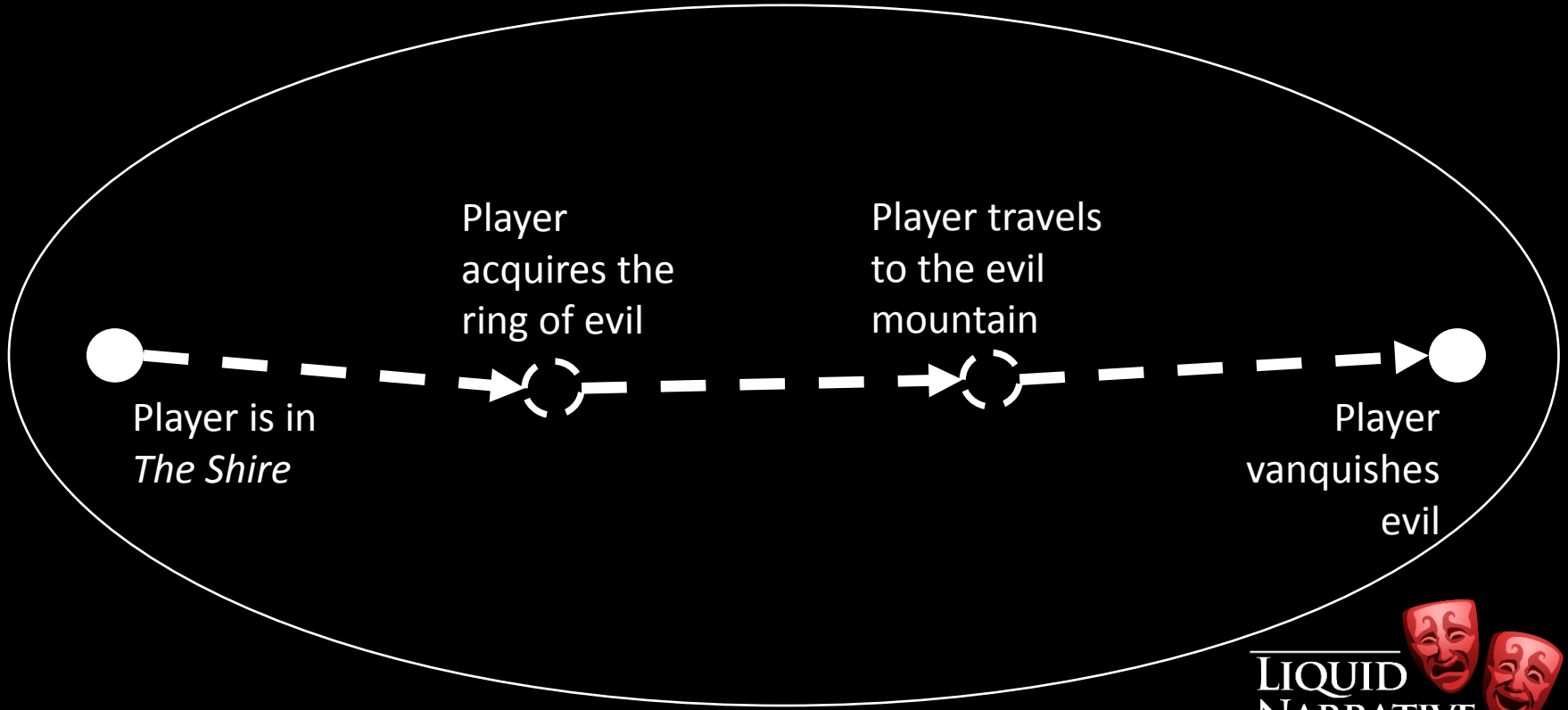

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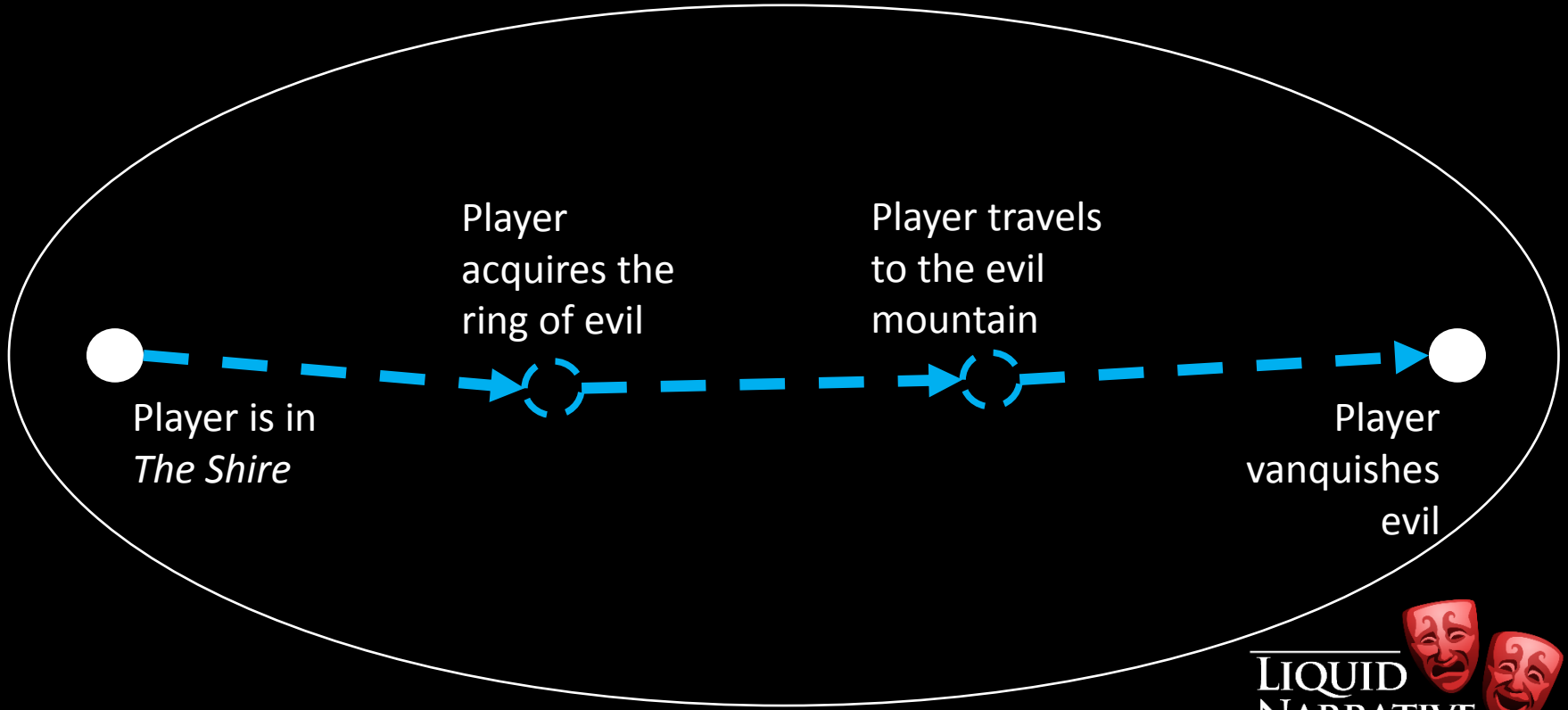

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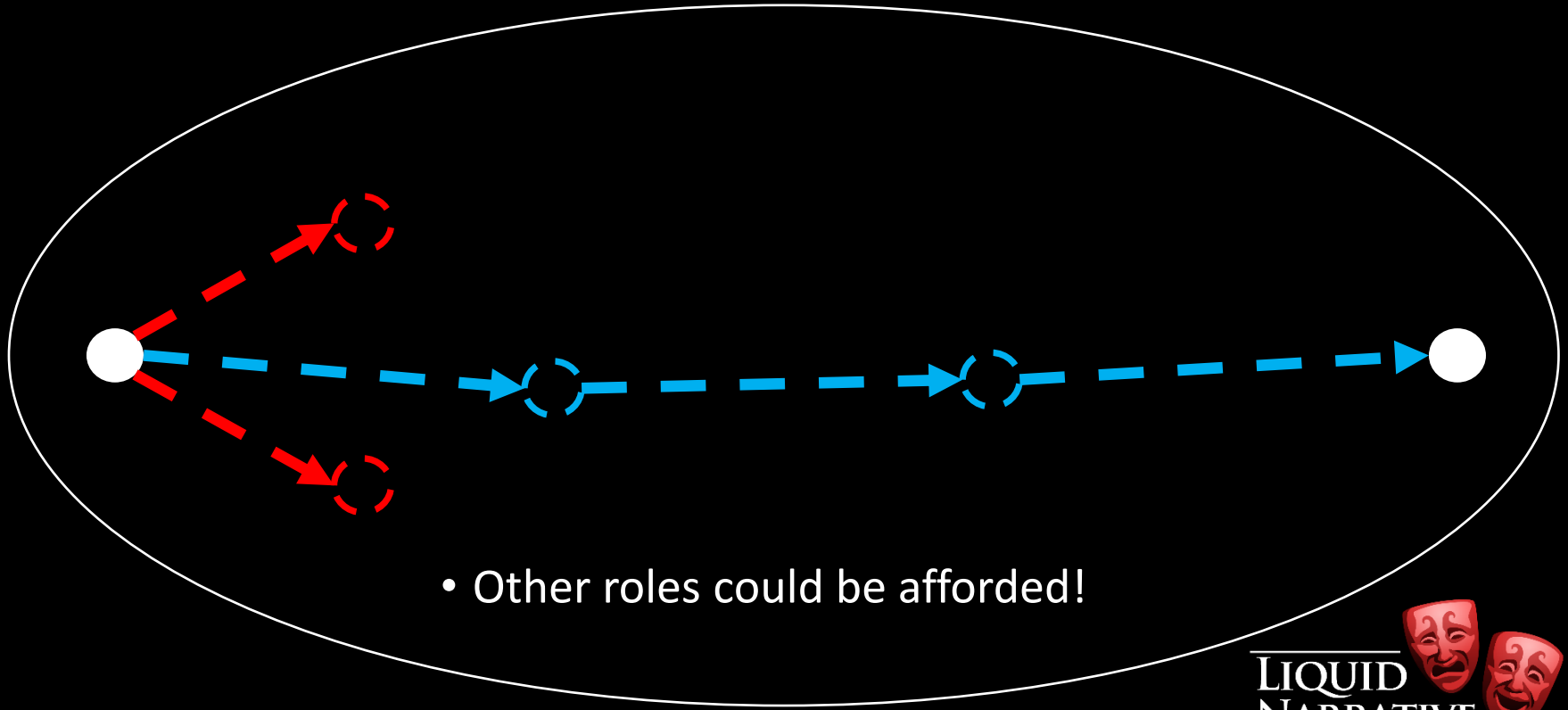

- Other roles could be afforded!

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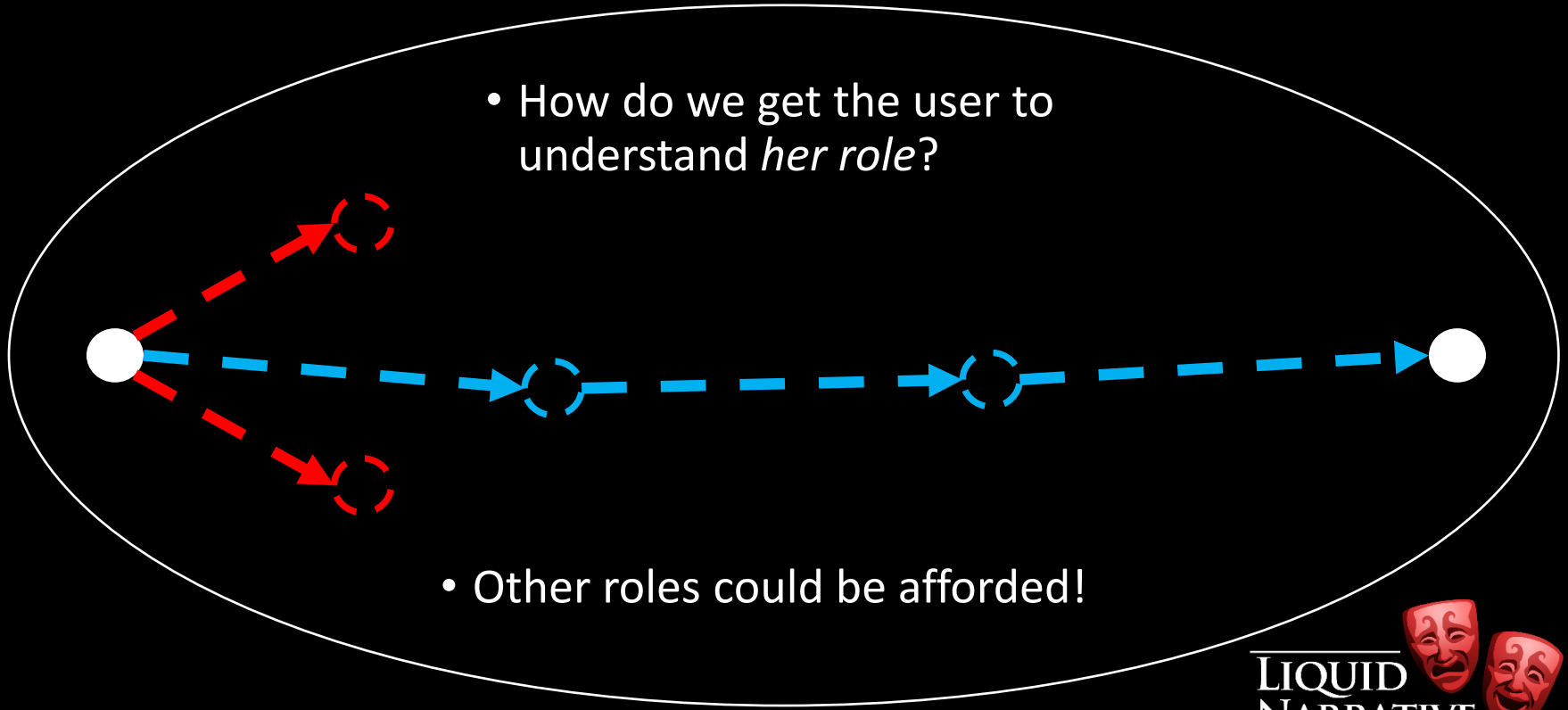
A Key Interactive Narrative Challenge:



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Roadmap

- The Vision
- Automated Planning and Computational Models of Narrative
- The *Experiential Goldilocks Problem* and *Narrative Affordances*
- Approach: Plan Recognition with Narrative Memory
- Q&A

Roadmap

- ~~The Vision~~
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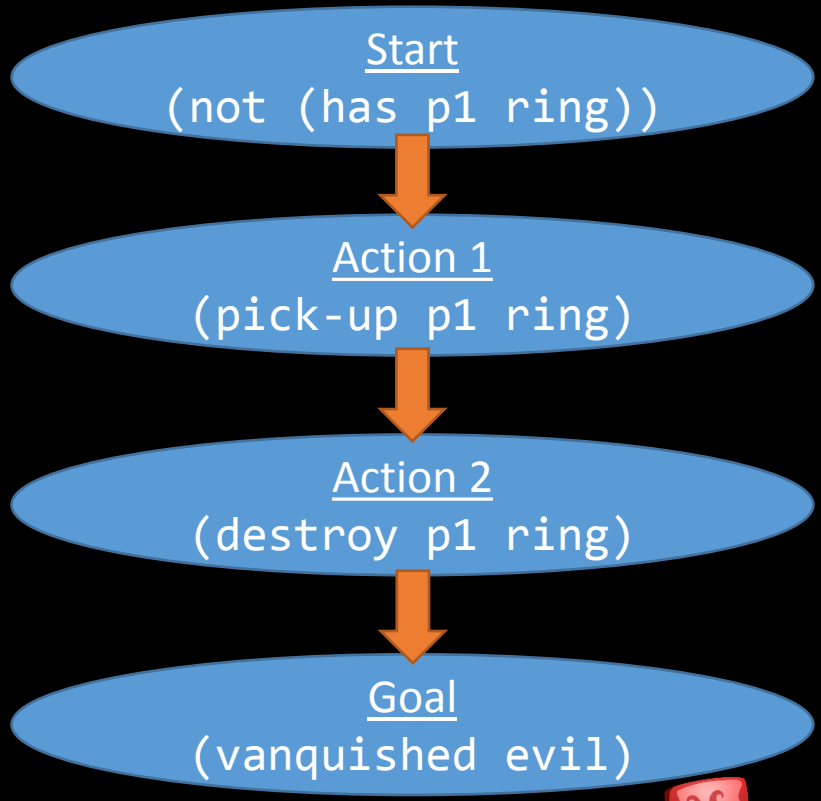
Automated Planning and Computational Models of Narrative

The Paradigm of *Narratives as Plans*

Automated Planning

- Automated planning is the *computational study of problem solving* (PSPACE-complete in general)
- Input:
  - Formal description (predicate logic based) of a state of the world
  - a desired goal state
  - a set of actions
    - With preconditions and effects
- Output: the sequence of actions that transform the current state into the desired goal state



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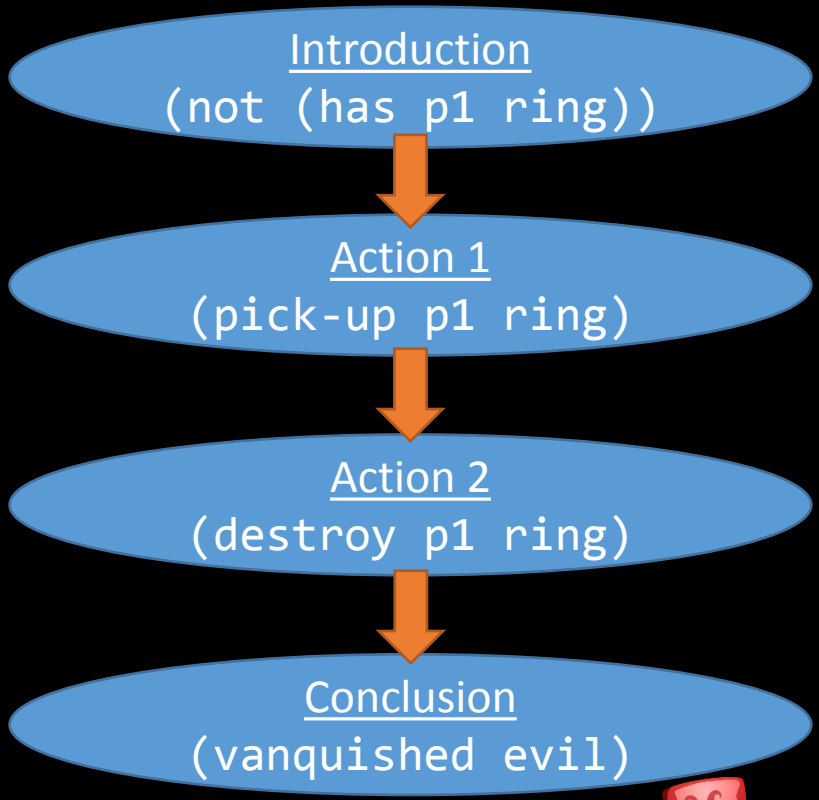
Narrative Planning

- Narrative planning is the *automated planning-based study of narrative authorship and its delivery to a story consumer*
- We borrow the formalism of automated planning, but this could lead to some undesirable effects
  - NOTE: These effects are not the main focus of my work, but give a flavor of what my work tries to do



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Once upon a time…

…there was a happy troll. The happy troll had an axe. The happy troll killed himself. The happy troll was dead.

- Example of an “efficient” story
- Because we borrow the paradigm of planning, we will likely find *structurally coherent stories*
  - But there are additional problems: stories ought to be *believable*, and *interesting*
  - Therefore, we must expand the knowledge representation to account for narrative-theoretic phenomena
  - In my case, the phenomena is narrative memory

The Experiential Goldilocks Problem and Narrative Affordances

Not too obscure, not too prosaic…just right.

The Elder Scrolls V: Skyrim – Understanding utterances

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Discourse Generation to Elicit Action

- This example shows what my proposed AI system aims to achieve: generate discourse content that prompts action
- It can say too little (the experience is too terse)
- It can say too much (the experience is too prosaic)
- Ideal: say just enough and no more

The Experiential Goldilocks Problem

Cardona-Rivera, R. E. & Young, R. M.; Games as Conversation. In *Proceedings of the 3rd Workshop on Games and NLP at the 10th AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment*, pp. 2-8, 2014.

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Foreseeing outcomes

- In this instance, you can *foresee a completion to your current story experience* given what is uttered in the game discourse
  - I call this a narrative affordance – sequences of actions you foresee as completions to your interactive experience
- Some inferences are more satisfying than others
  - The Experiential Goldilocks Problem is about eliciting the right set of inferences

Young, R. M., & Cardona-Rivera, R. (2011). Approaching a Player Model of Game Story Comprehension Through Affordance in Interactive Narrative. In *Intelligent Narrative Technologies*.

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Approach:
Plan Recognition with Narrative Memory

Modeling inference-making as a plan recognition process

Players are Problem Solvers and Plan Recognizers

- Players make inferences because they act as a problem solvers trying to anticipate solutions to narrative situations
- Players also ascribe intent to the interactive narrative designer's plans (plan recognition – a form of problem solving)
- Key to narrative problem solving performance is the role of *narrative working memory*
  - Allows people to draw connections between concepts

Gerrig, R. J., & Bernardo, A. B. (1994). Readers as problem-solvers in the experience of suspense. *Poetics*, *22*(6), 459-472.

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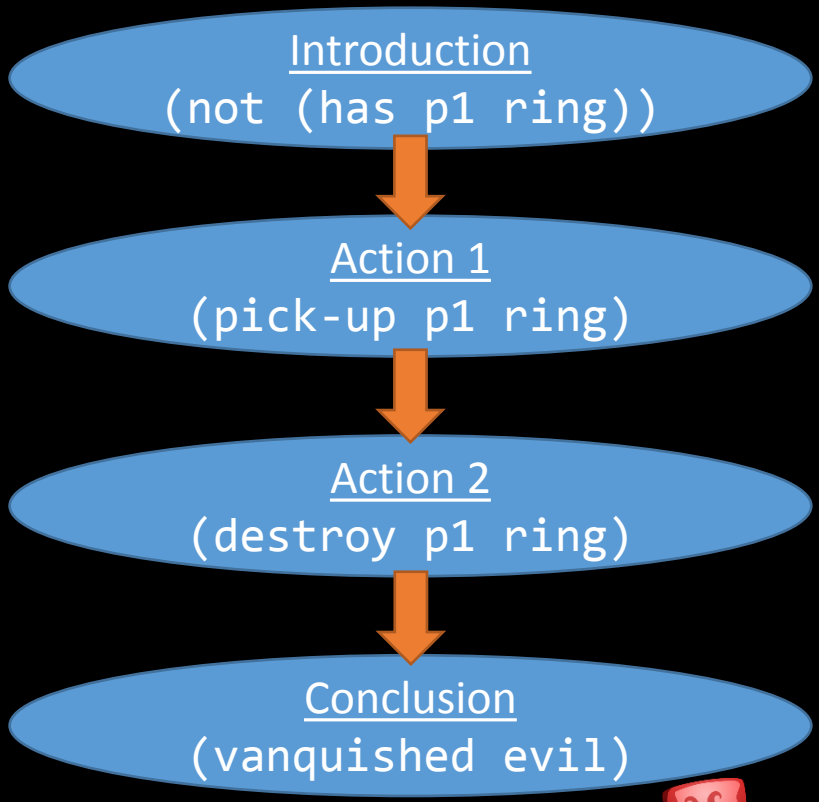
Narrative Memory: The Event-Indexing Model

- A model of narrative comprehension with respect to memory
- As we consume stories, we discretize them into their constituent events
- We additionally "tag" these events along 5 dimensions (or indices)



Zwaan, R. A., et al. (1995). The Construction of Situation Models in Narrative Comprehension, An Event-Indexing Model. Psychological Science, 6(5):292-297.

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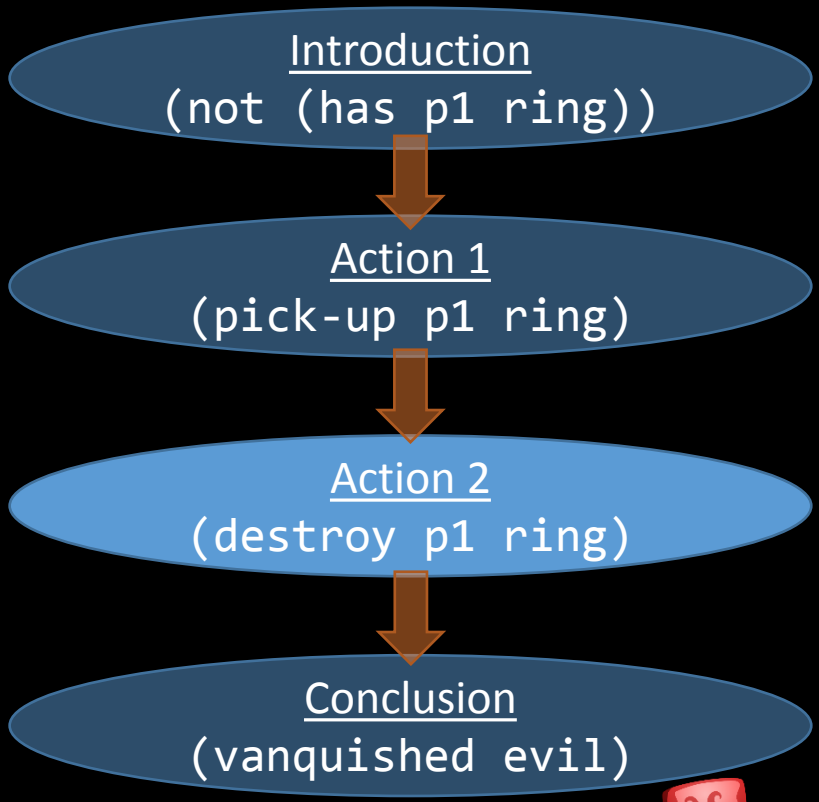
Narrative Memory: The Event-Indexing Model

- 5 Dimensions/Indices:

1. Space
   - Mount Doom
2. Time
   - Index 2
3. Causality
   - Main Causal Chain
4. Intentions
   - Goal to destroy the ring
5. Entities
   - p1, ring



Zwaan, R. A., et al. (1995). The Construction of Situation Models in Narrative Comprehension, An Event-Indexing Model. Psychological Science, 6(5):292-297.

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Indexter: Computational Model of the EIM

- I co-developed a computational implementation of this cognitive model in an automated planning context

$$recallability(e_i^*, q, C) = \frac{overlap(e_i^*, q)}{\sum_{e_i \in C} overlap(e_i, q)} \quad (1)$$

$$overlap(e_x, e_y) = \#\text{ of index values shared by } e_x \text{ and } e_y \quad (2)$$

- Recallability is dimensionless, but allows relative ranking between narrative events

Cardona-Rivera, R. E., & Young, R. M. (2014). A Knowledge Representation that Models Memory in Narrative Comprehension. In 28th *AAAI Conference on Artificial Intelligence*

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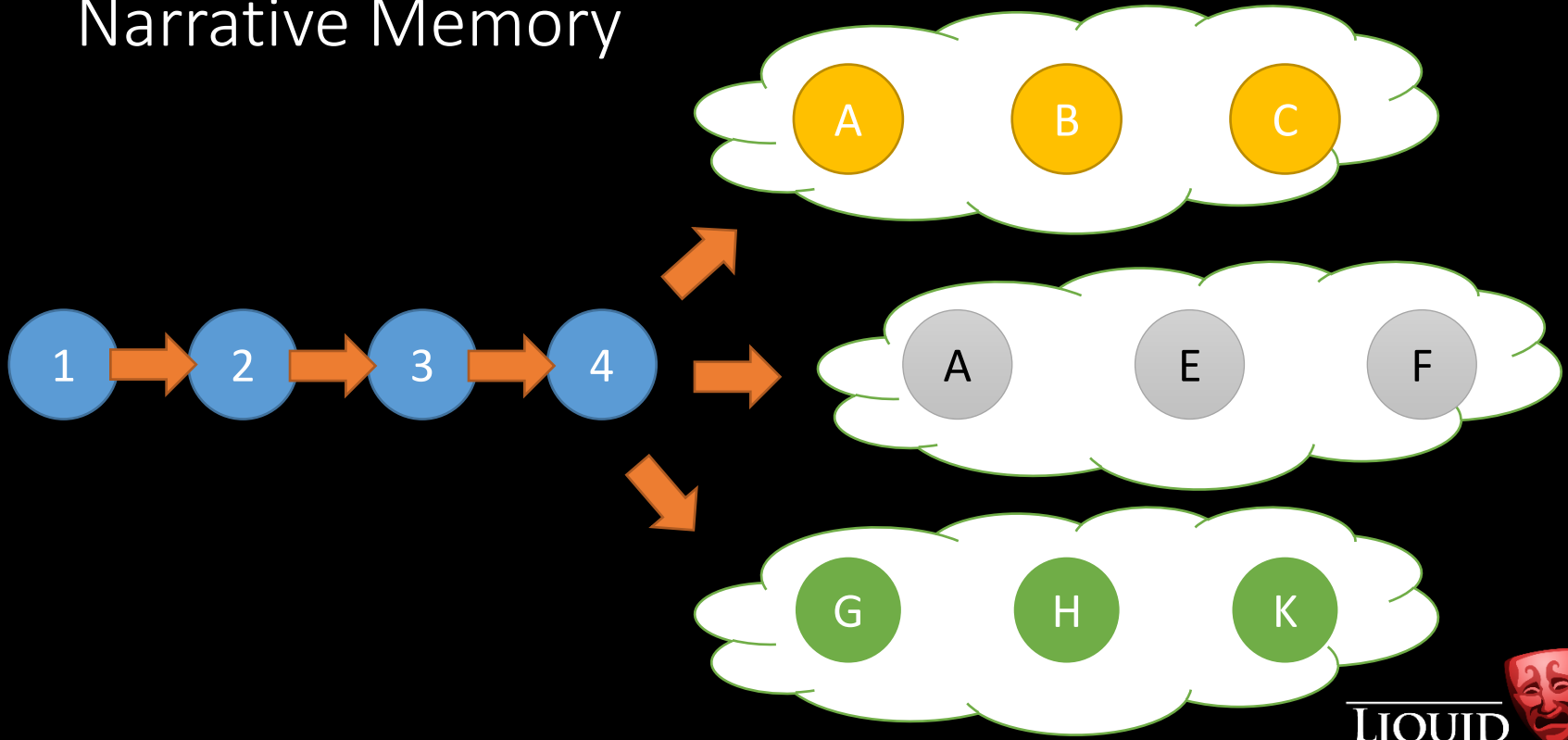
Proposed Work: Constrain Plan Recognition with Narrative Memory



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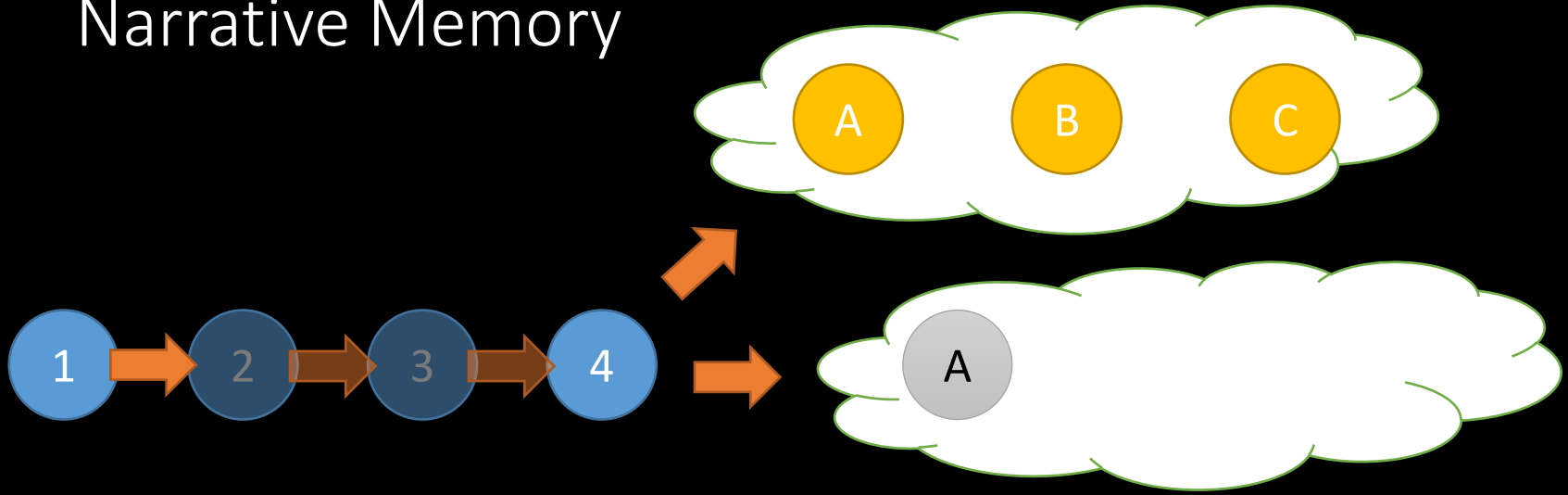

- Narrative memory would filter out inferences that are not related to the concepts active in narrative memory
- Algorithm development + experimental validation forthcoming!

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Recap

There and back again.

Recap – Q&A Session

- Computational Models of Interactive Narratives could help identify commonalities between narratives as a target of interpretation and narrative for sense-making
- AI can help *procedurally generate content*, but it must carry the burden of a content creator; i.e. it must be sensitive to the Goldilocks Problem
- I use the paradigm of automated planning (a PSPACE problem in general) to model narrative comprehension and reasoning
- I developed a planning-based model of narrative memory
- Proposed work to use this model to inform a plan recognition based narrative inference-making model
- This inference-making model would inform discourse generation that is sensitive to the Goldilocks Problem

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