

# ICAPS 2024 Tutorial on Narrative Planning

**Rogelio E. Cardona-Rivera, Ph.D.**

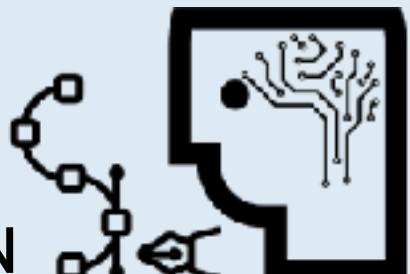
**Division of Games, University of Utah, Salt Lake City, UT, USA**

**Based upon work supported by the**



**United States National Science Foundation under award**

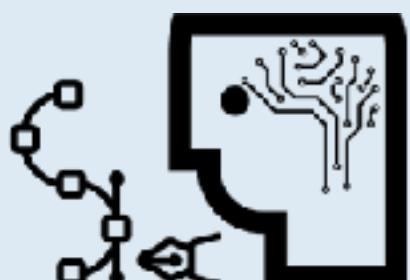
**CAREER: Plan-based Simulation of Human Story Understanding (Grant No. 2046294)**



# **The Story So Far on Narrative Planning**

## **The #ICAPS24 Paper Version of my Slides**

<https://tinyurl.com/narrative-planning-survey>



# Tutorial Overview

- **Act I: From Classical to Narrative Planning** (30 minutes)
- **Act II: Unique Narrative Planning Facets** (30 minutes)
  - ▶ Coffee Break! (30 minutes)
- **Act III: Narrative Domains & Expressive Range** (30 minutes)



This tutorial is meant to be highly interactive!

Follow along with the DEMO PACKAGE available  
at: <https://tinyurl.com/icaps24-glaive>



# Glaive

[cs.uky.edu/~sgware/projects/glaive/](http://cs.uky.edu/~sgware/projects/glaive/)

- Requires **Java 7**
- Available as a (Java) .jar
- Includes several narrative domains

- ▶ Aladdin, Ark, Fantasy, Heist, Space, Western

- I will use it in all acts of my tutorial presentations



Proceedings of the Tenth Annual AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment (AIIDE 2014)

## Glaive: A State-Space Narrative Planner Supporting Intentionality and Conflict

**Stephen G. Ware**  
sgware@uno.edu  
Computer Science Department  
University of New Orleans  
New Orleans, LA, USA

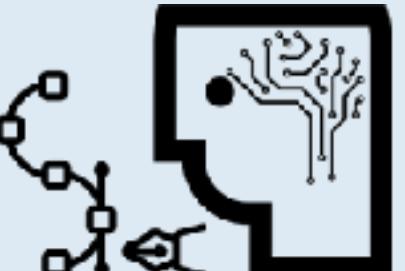
**R. Michael Young**  
young@cs.ncsu.edu  
Liquid Narrative Group, Computer Science Dept.  
North Carolina State University  
Raleigh, NC, USA

Ware, S., & Young, R. M. (2014). *Glaive: A State-Space Narrative Planner Supporting Intentionality and Conflict*. In Proceedings of the 10th AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment (pp. 80-86).



# From Classical to Narrative Planning

**Why use automated planning for narrative in the first place?**



An intelligent person  
or program should  
be able to answer  
[...] questions  
based on [...]  
information in [a]  
story



McCarthy, J. (1990). An Example for Natural Language Understanding and the AI Problems it Raises. *Formalizing Common Sense: Papers by John McCarthy*, 355.

**Natural science is knowledge about natural objects and phenomena. We ask whether there cannot also be "artificial" science knowledge about artificial objects and phenomena.**

# The Role of Narrative

## A Fundamentally Human Phenomenon

video games

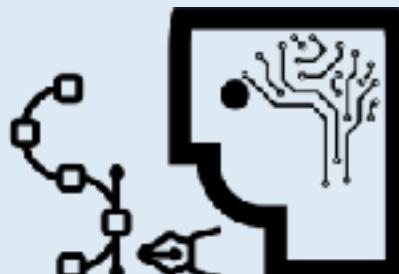


- Narrative makes interaction more compelling
  - ▶ Entertainment
  - ▶ Education
  - ▶ Engagement
- **We do not yet understand how to predictably elicit the power of narrative**
- Automated Planning offers *systematicity* to a Science of Narrative

training simulations



gamification



# On Invariants

## ...in Natural Phenomena

- Predictive relationship that relates quantities of interest

$$F = m \times a$$

Outer  
environment  
(People)

## ...in Artificial Phenomena

- Predictive relationship that relates quantities of interest

$$O = I \times C$$

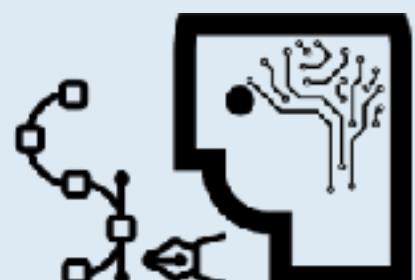
Inner  
environment  
(Artifact)



# You will understand narrative planning aims, themes, and methods

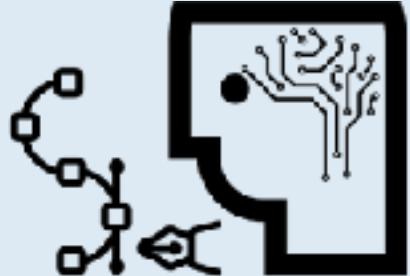
## Presentation Objective

- The Classical Basis
- The Different Layers of Narrative
- The Different Modeling Methods



# The Classical Basis

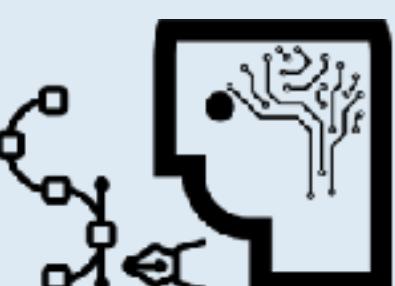
## Re-interpreting Familiar Ingredients



# Narratives as Plans

## Formal Preliminaries

- Story generation as a classical planning problem  $P = \langle \mathcal{L}, I, A, G, f_{\text{cost}} \rangle$ 
  - ▶  $\mathcal{L}$  : set of atomic wff or their negations
  - ▶  $I \subseteq \mathcal{L}$  : initial (closed world) state
  - ▶  $G \subseteq \mathcal{L}$  : goal conditions
  - ▶  $\forall a \in A: a = \langle \text{PRE}(a) \subseteq \mathcal{L}, \text{ADD}(a) \subseteq \mathcal{L}, \text{DEL}(a) \subseteq \mathcal{L} \rangle$  : actions
- Search for sequence to transform  $I \rightarrow G$



**What does  
 $P = \langle \mathcal{L}, I, A, G, f_{\text{cost}} \rangle$**   
represent?

In...  
**Classical**

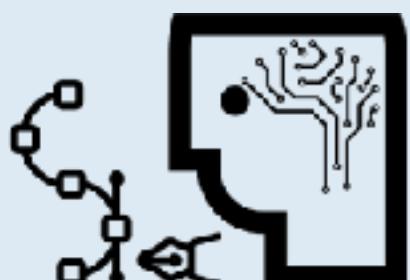
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**A Task  
Environment**

**Narrative**

---

**Authorial  
Intent**



# Narratives as Plans

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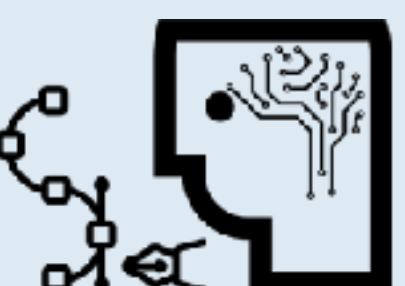
# Previously...



# Narratives as Plans

## Formal Preliminaries

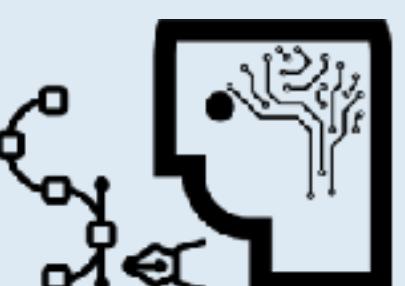
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- Search for sequence to transform  $I \rightarrow G$



# Narratives as Plans

## Formal Preliminaries

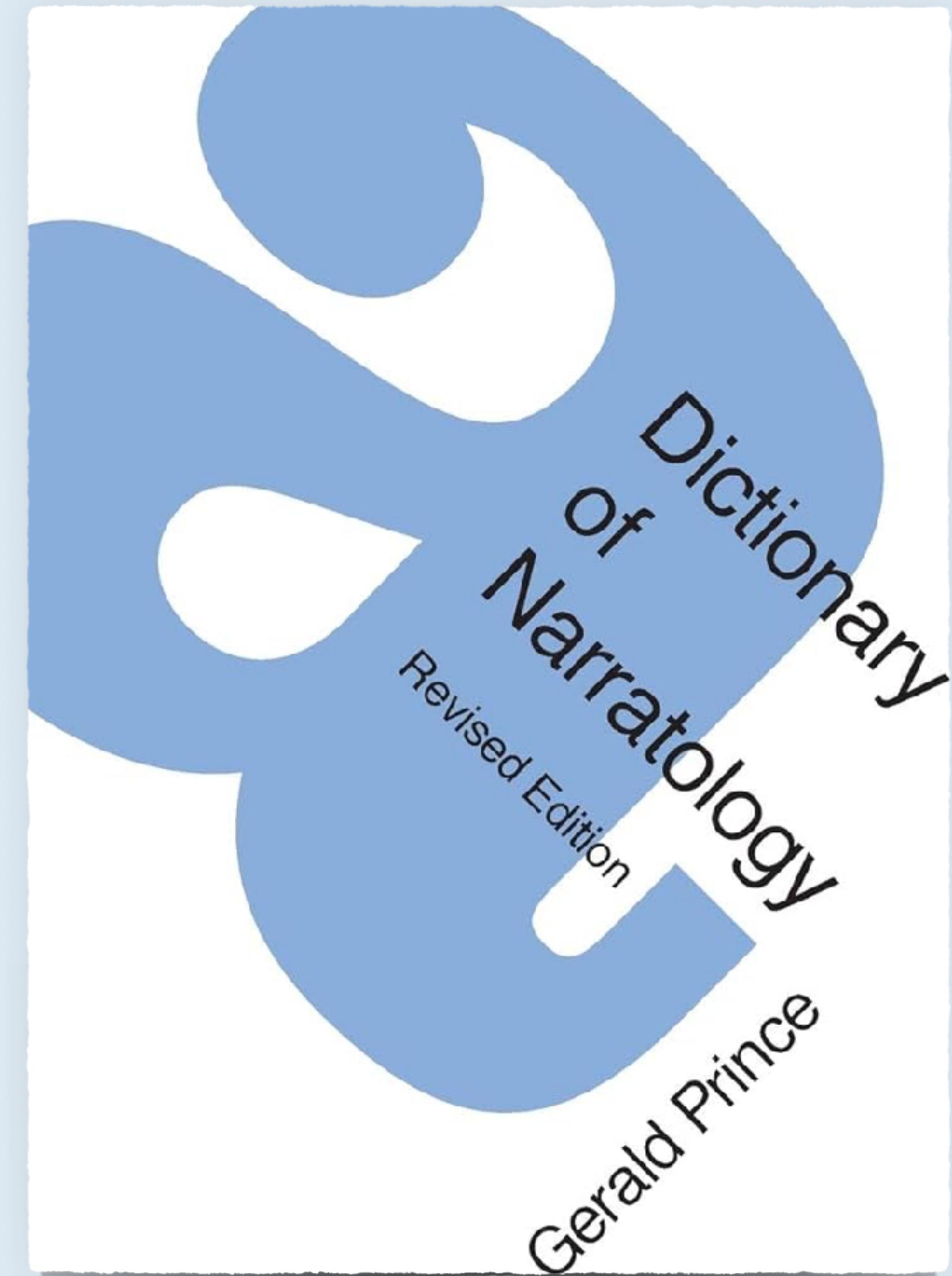
- Story generation as a classical planning problem  $P = \langle \mathcal{L}, I, A, G, f_{\text{cost}} \rangle$ 
  - ▶  $\mathcal{L}$  : **virtual world ontology**
  - ▶  $I \subseteq \mathcal{L}$  : initial (closed world) state
  - ▶  $G \subseteq \mathcal{L}$  : goal conditions
  - ▶  $\forall a \in A: a = \langle \text{PRE}(a) \subseteq \mathcal{L}, \text{ADD}(a) \subseteq \mathcal{L}, \text{DEL}(a) \subseteq \mathcal{L} \rangle$  : actions
- Search for sequence to transform  $I \rightarrow G$



# Virtual World Ontology

## From *Structuralist Narratology*

- Events: changes in states of affairs that occur in *spacetime*
  - Happenings: not intended by characters
  - Actions (non-happenings): intended by characters
- States: set of conditions describing a situation
- Characters: anthropomorphized, intention-driven agents



Prince, G. (2003). *A Dictionary of Narratology*.  
University of Nebraska Press.

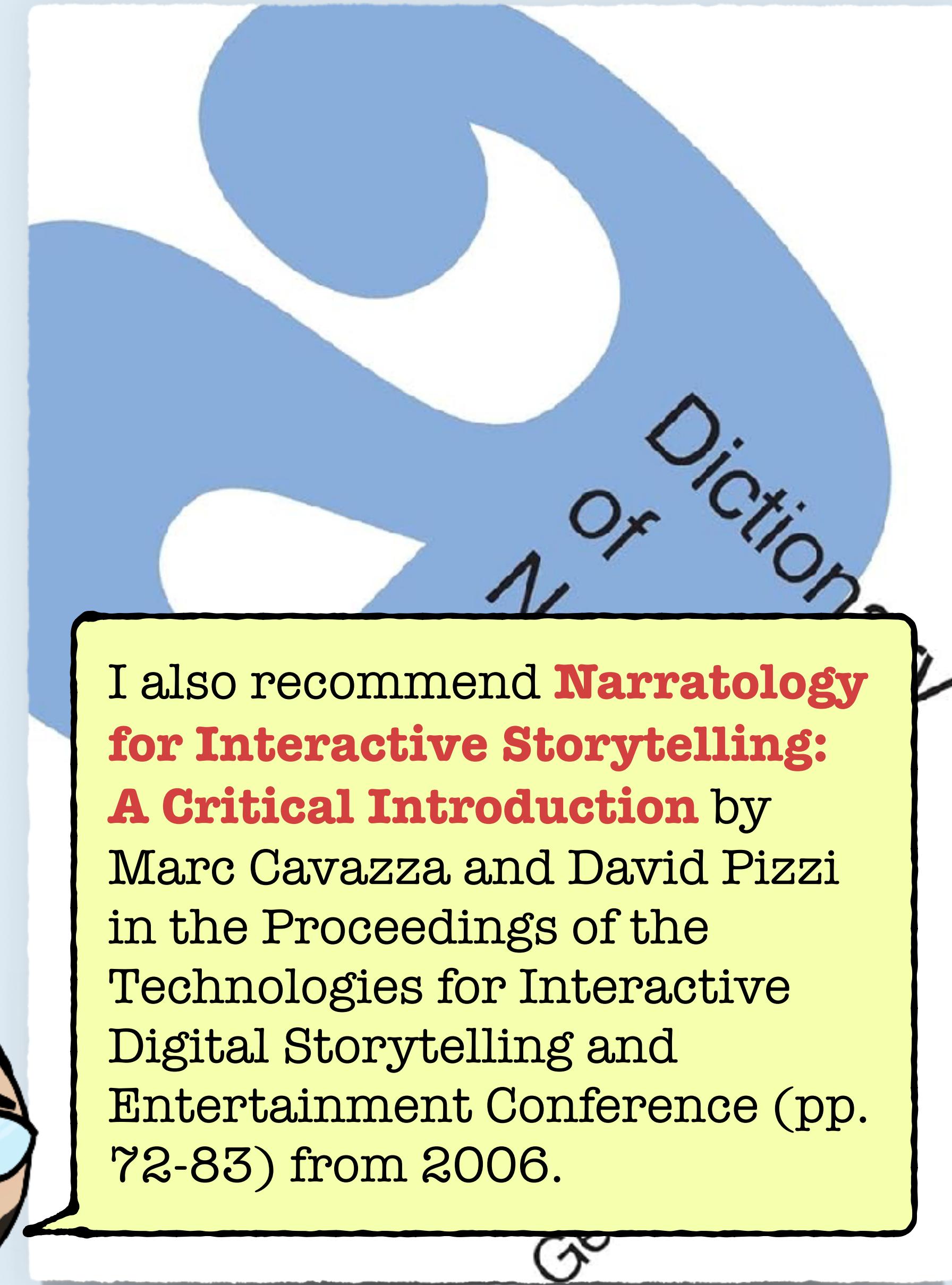


# Virtual World Ontology

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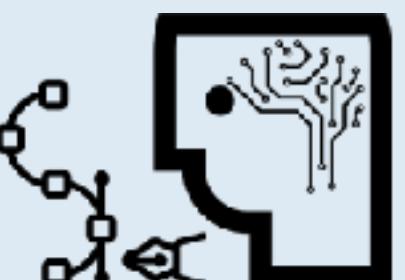
I also recommend **Narratology for Interactive Storytelling: A Critical Introduction** by Marc Cavazza and David Pizzi in the Proceedings of the Technologies for Interactive Digital Storytelling and Entertainment Conference (pp. 72-83) from 2006.



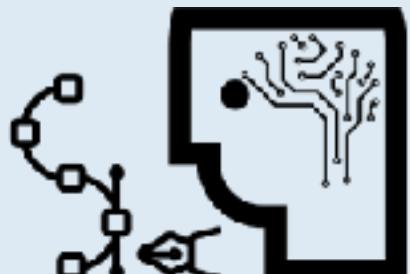
# Narratives as Plans

## Formal Preliminaries

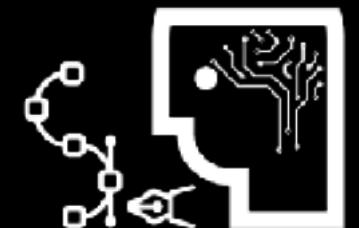
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  - ▶  $\mathcal{L}$  : **virtual world ontology**
  - ▶  $I \subseteq \mathcal{L}$  : initial (**design open** world) state — *whatever is authorially needed*
  - ▶  $G \subseteq \mathcal{L}$  : **intended story outcomes**
  - ▶  $\forall a \in A: a = \langle \text{PRE}(a) \subseteq \mathcal{L}, \text{ADD}(a) \subseteq \mathcal{L}, \text{DEL}(a) \subseteq \mathcal{L} \rangle$  : **story events**
- Search for sequence to transform  $I \rightarrow G$ ,  $\pi$  : **narrative plan**



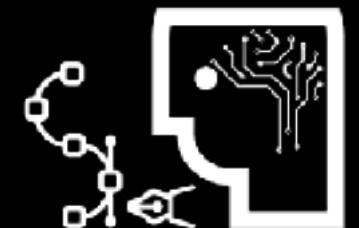
**So...  
we're done?**



No.



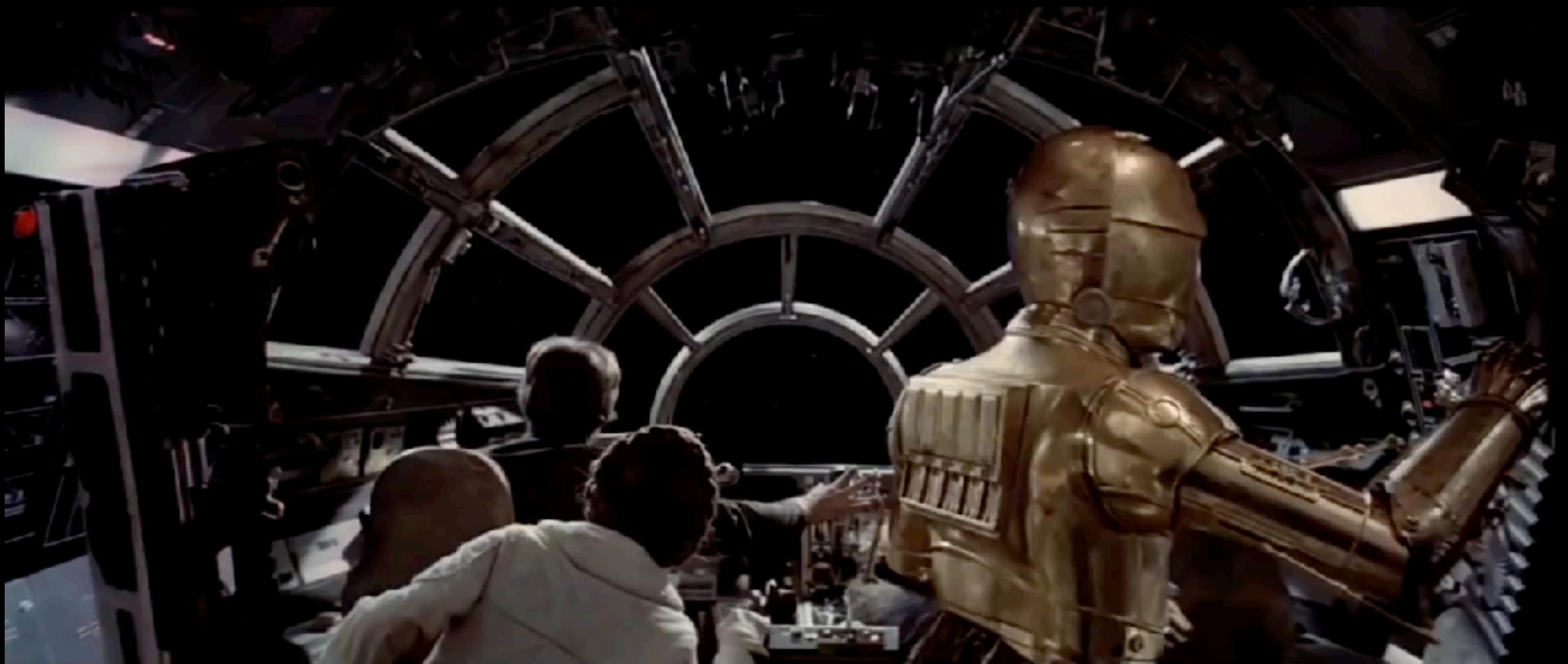
# Consider...



# Case Study: The Asteroid Field in SWEPV

An ecologically valid example of why KR is not enough

- Scene: *The Asteroid Field* from **Star Wars: Episode V**
- Two-part Exercise:
  1. **Notice** what happens
  2. **Wonder** why KR is not enough



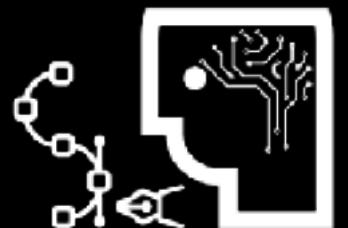
# Crew of the Millennium Falcon

## A kooky set of non-rational agents

- Han:
  - *Decides for and endangers everyone*
  - *Fails to accomplish intent*
- C-3P0:
  - *Fails to communicate ship status*
- In truth: the ***director*** planned everyone's plans to fail ***in specific ways***



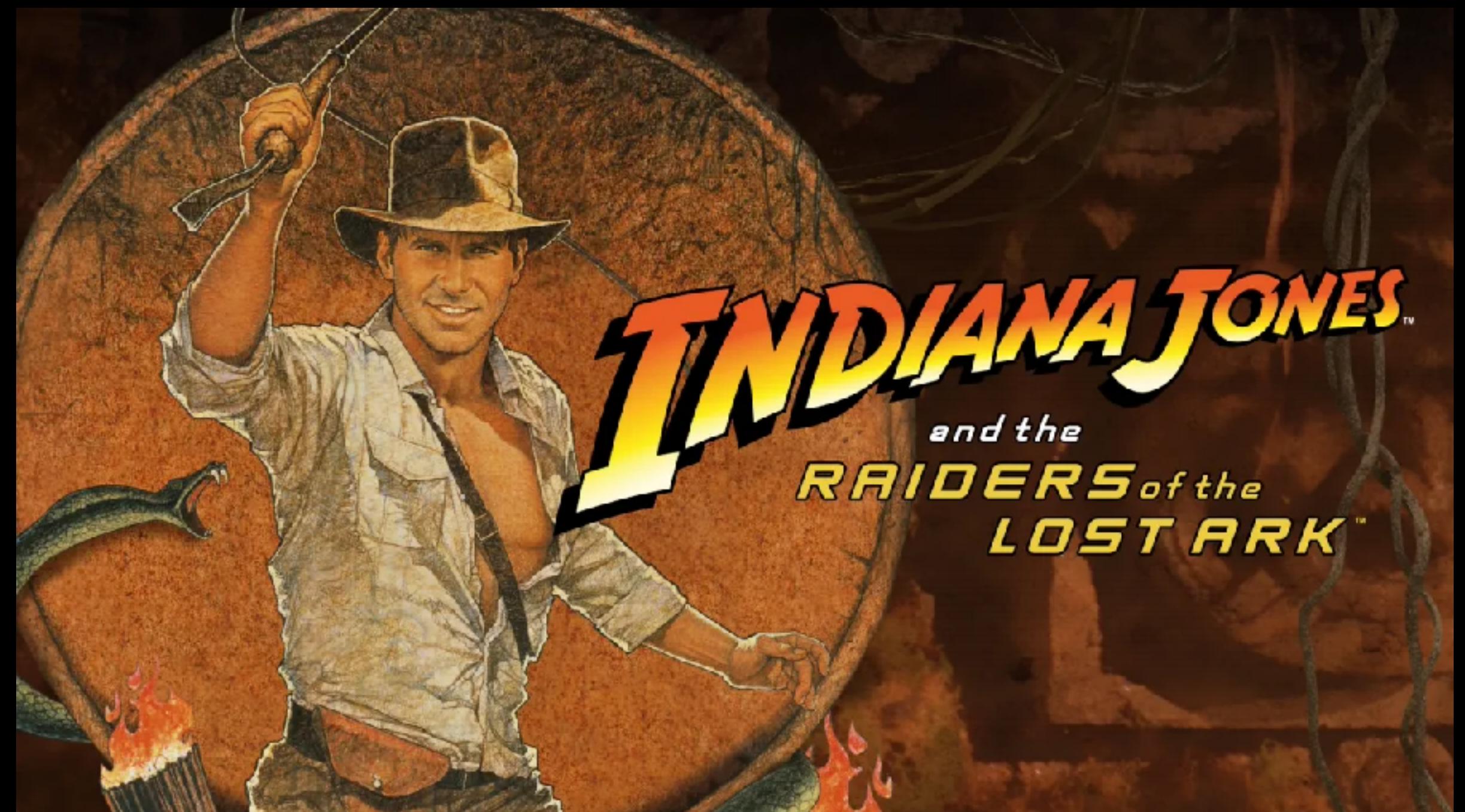
This is nice and abstract...  
...what of the plan structures?



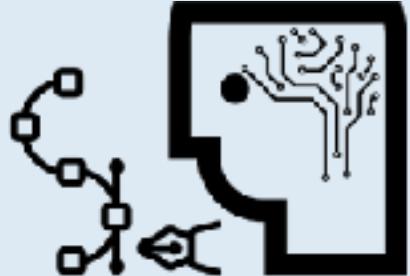
# Let me try to tell you another story...

The story may seem familiar to you

- It involves:
  - ▶ Two groups: good 🕵️ and evil 😈 who both want a deadly treasure 💀 *hidden in Egypt* 🇪🇬
  - ▶ A tenured professor of Archeology 😊 from the United States 🇺🇸 who *knows where the treasure* 💀 *is*
- Any similarity to actual stories is purely coincidental



# The Ark Domain



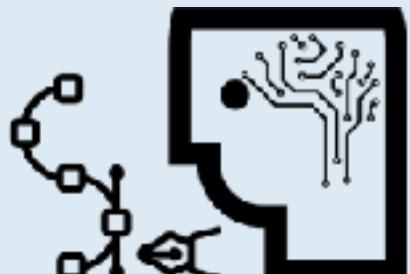
# GLAIVE demo

## Ark Domain

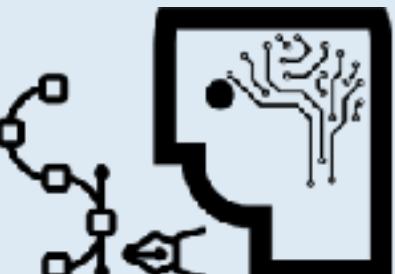
- The :intentionality flag is *needed* for Glaive
- Everything else is classically defined
- Included in icaps2024 demo folder
  - ▶ run with:  
java -jar glaive  
-d <domain-file>  
-p <problem-file>

```
; ; classical-ark-domain.pddl
(:requirements
  :adl :domain-axioms :intentionality)
(:types character place item - object
  weapon - item)
(:constants ark - item)
(:predicates (open ark) (alive ?c - character)
  (armed ?c - character)
  (buried ?i - item ?p - place)
  (knows ?c - character ?i - item ?p - place)
  (at ?c - character ?p - place)
  (has ?c - character ?i - item))
(:action travel ...) (:action excavate ...)
(:action give ...) (:action eliminate ...)
(:action take ...) (:action open-ark ...)
(:action close-ark ...)
(:axiom /* has weapon means armed */ )
(:axiom /* not has weapon means not armed */ )
```

**Switch to  
The Ark Domain  
Code**



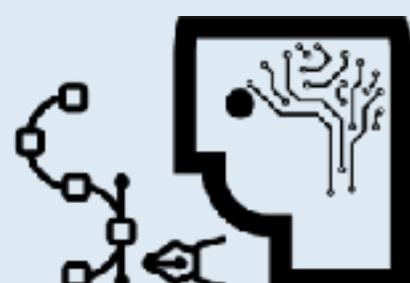
# Coffee Break



# You will understand narrative planning aims, themes, and methods

## Presentation Objective

- The Classical Basis
- The Different Layers of Narrative
- The Different Modeling Methods



# You will understand narrative planning **aims, themes, and methods**

## Presentation Objective

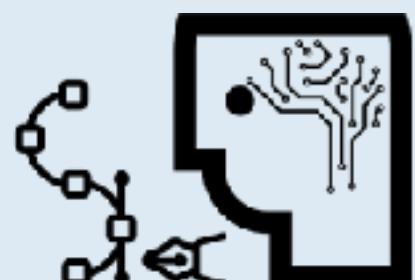
- The Classical Basis: Re-interpreting Familiar Ingredients
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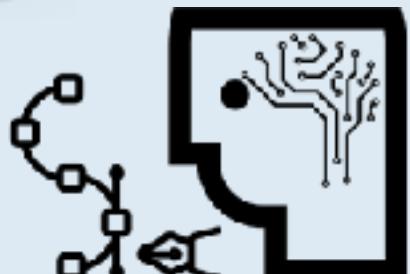
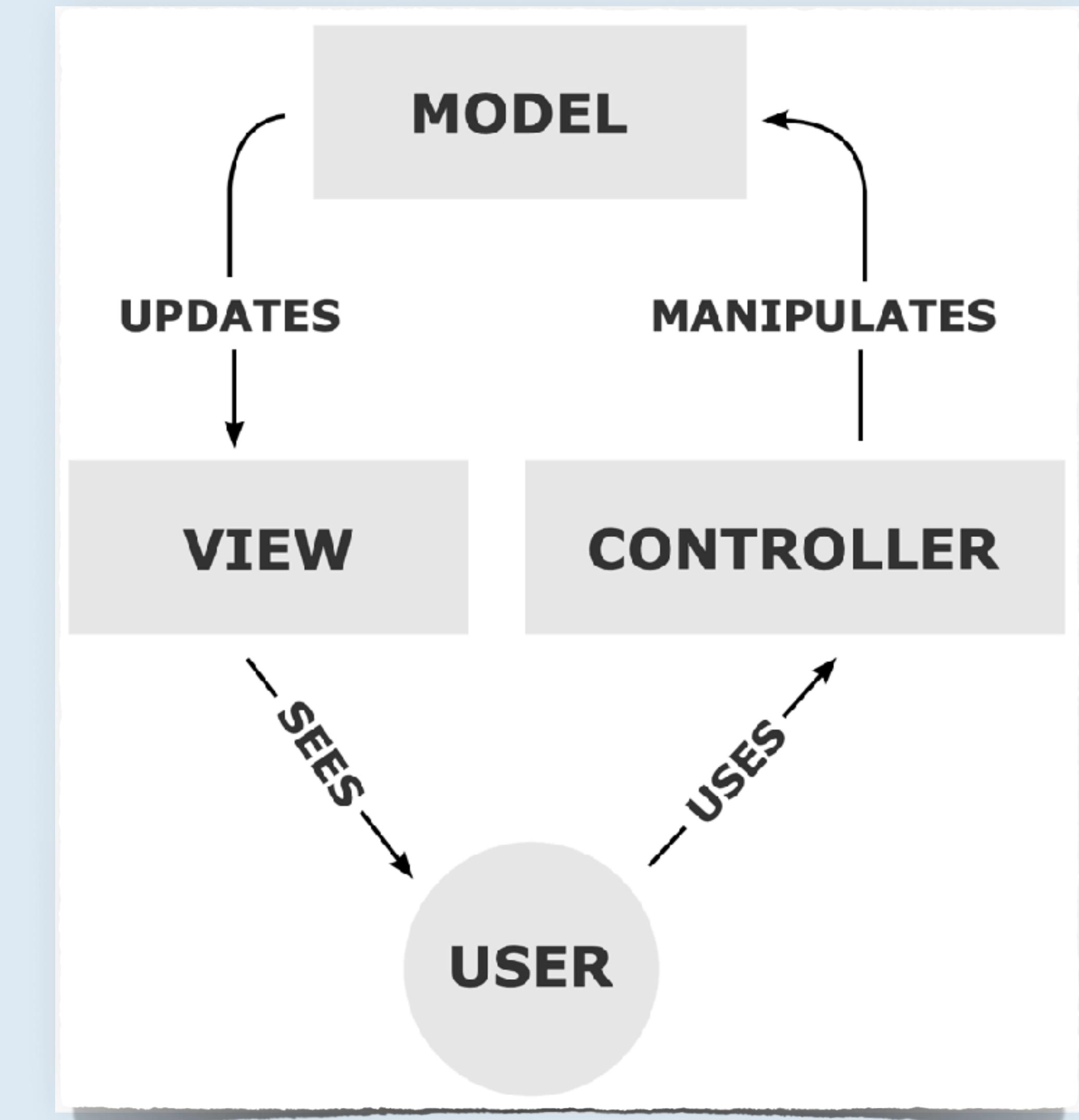
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# The Different Layers of Narrative

Or, a Story-centric  
“Model-View-Controller”



# Tripartite Model of Narrative

## Due to Narratology

### 1. The Plot, or **Narrative Virtual World**

- ▶ Locations, Characters, Events

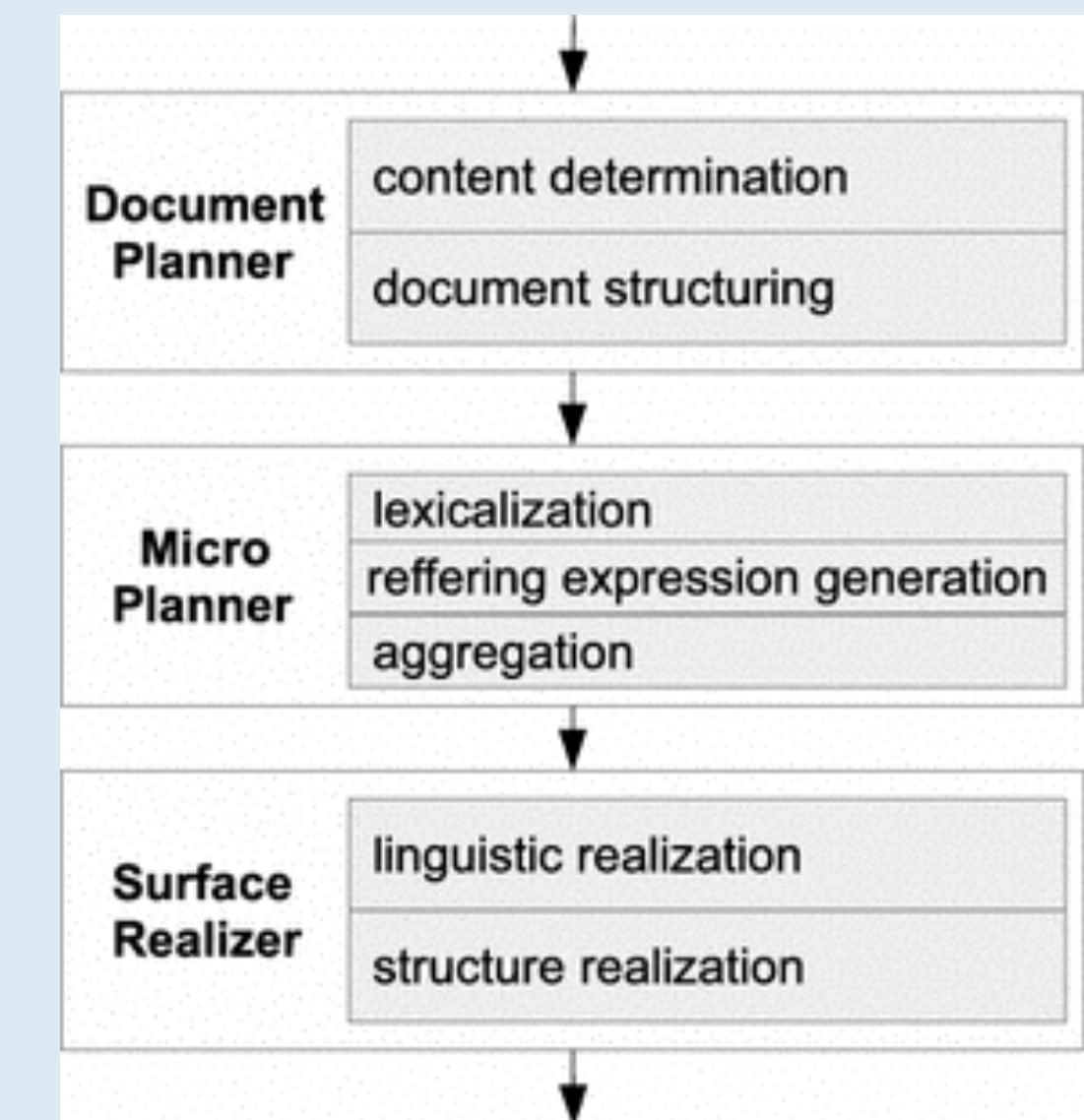
### 2. The Discourse, or **Author's Temporal Organization of What to Tell**

- ▶ Discursive Intent

### 3. The Narration, or **Surface Realization of Author's Telling**

- ▶ The Story *Artifact* itself  
(e.g., text, comic, movie, game)

Akin to...



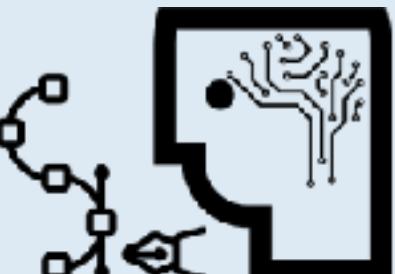
- ▶ Dale and Reiter's NLG Pipeline



# (Narrative) Discourse Planning

## Planning the **Telling** of the Narrative's Information

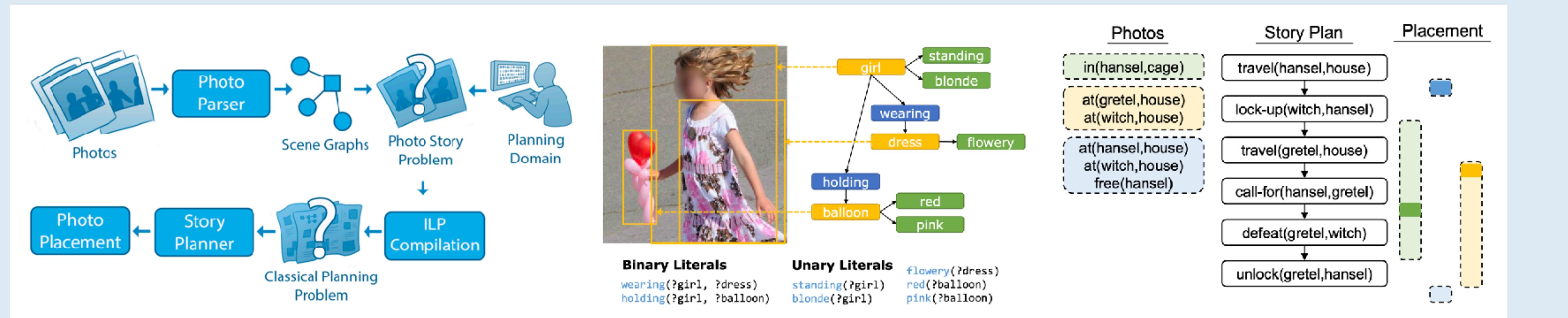
- Closest non-narrative planning analogue: **discourse planning**
- Exercise: How is it similar?
  - Planning of utterances
  - Operating in (audience) *belief space*
- Exercise: How is it different?
  - Concerned with more than the *final belief*; i.e., the *trajectory*
  - Can operate on the basis of what is *false*



# Narration Planning

## Planning the Production of the Narrative Artifact

- Closest non-narrative planning analogue: **NLG surface realization**
- Dearth of work in this area!
  - ▶ Example system: PLOTSHOT



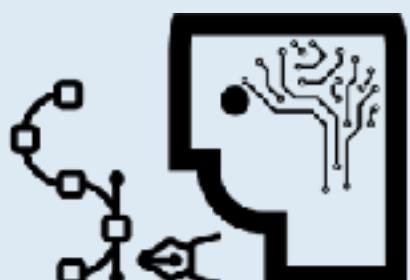
Cardona-Rivera, R., & Li, B. (2016). **PLOTSHOT: Generating discourse-constrained stories around photos**. In Proceedings of the 12th AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment (pp. 2-8).



# You will understand narrative planning **aims, themes, and methods**

## Presentation Objective

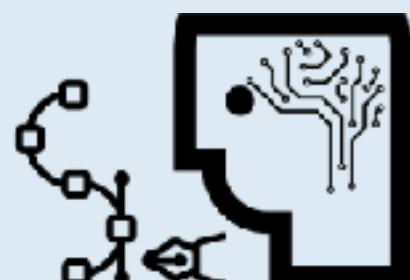
- The Classical Basis: Re-interpreting Familiar Ingredients
- The Different Layers of Narrative: A Story “MVC” – Plot, Discourse, Narration
- The Different Modeling Methods



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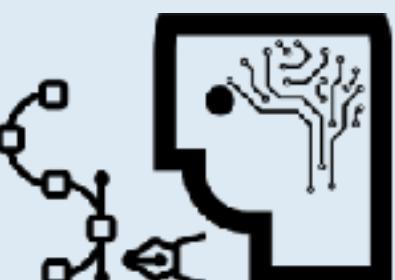
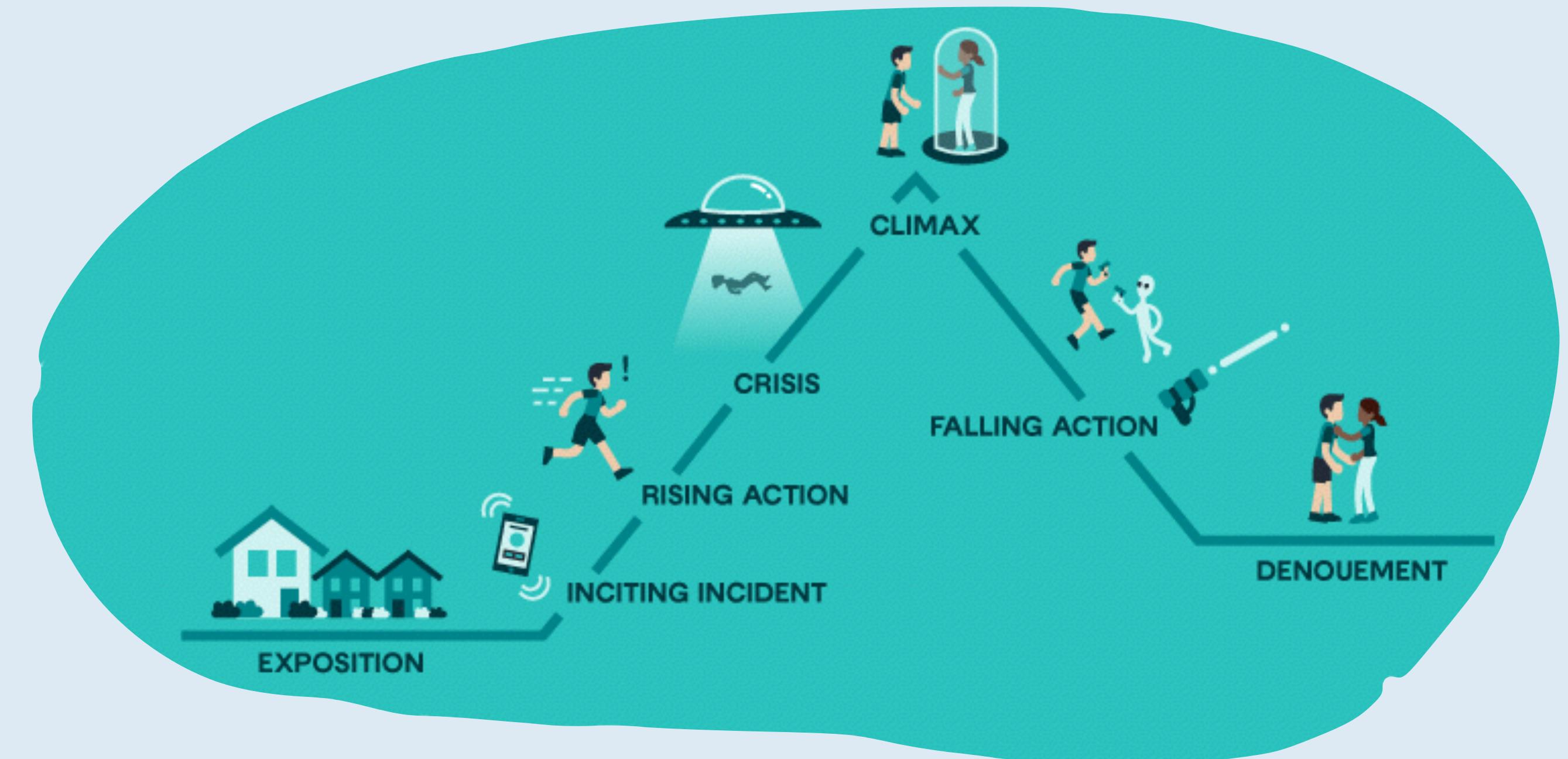
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# The Different Modeling Methods

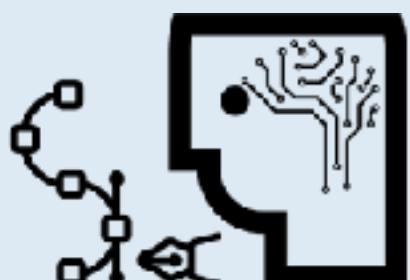
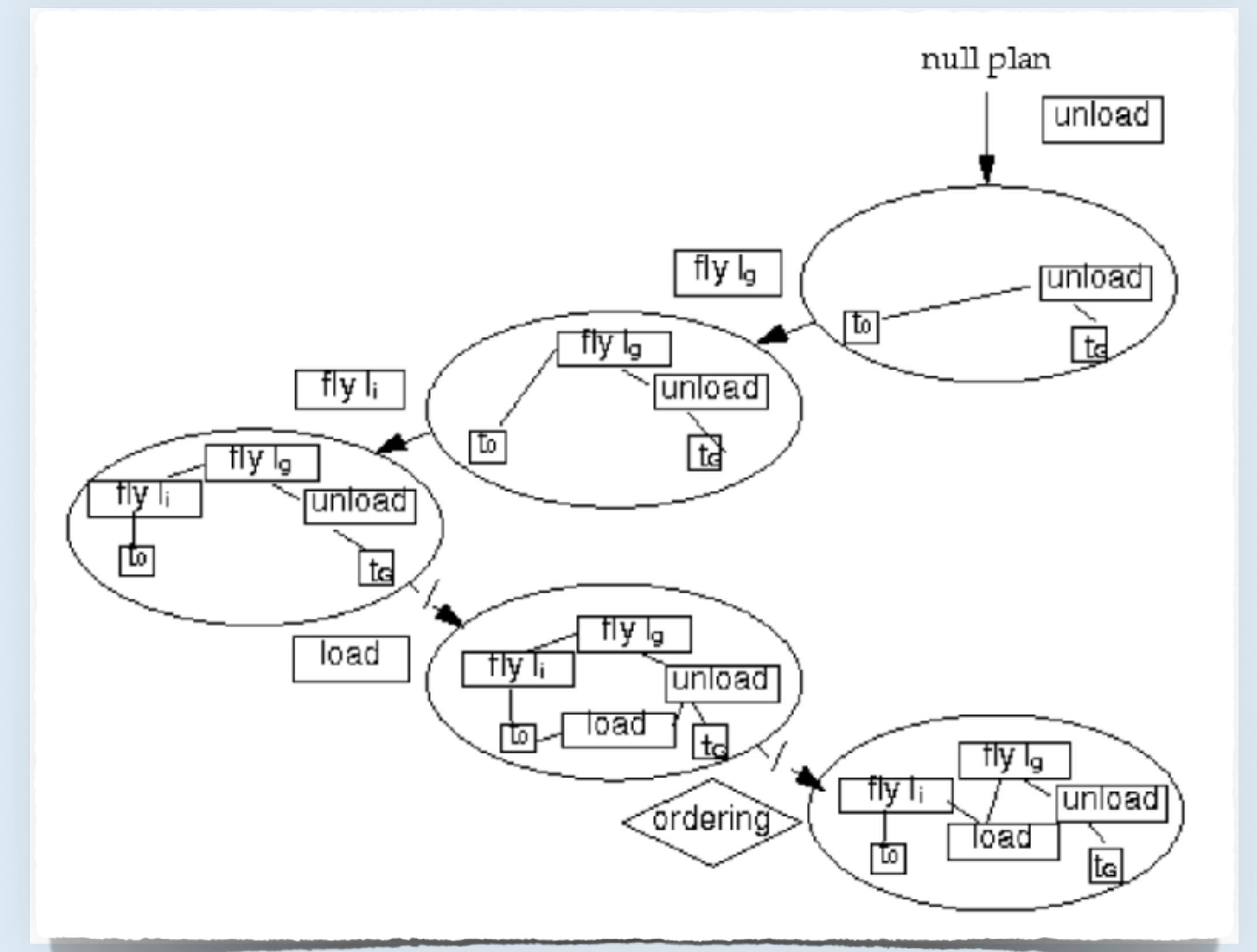
## How to codify narrative phenomena



# Plan Space Planning

## Modeling Narrative Phenomena in Terms of **Flaws** and **Fixes**

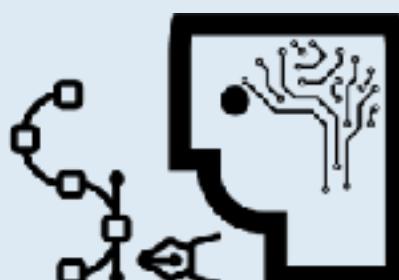
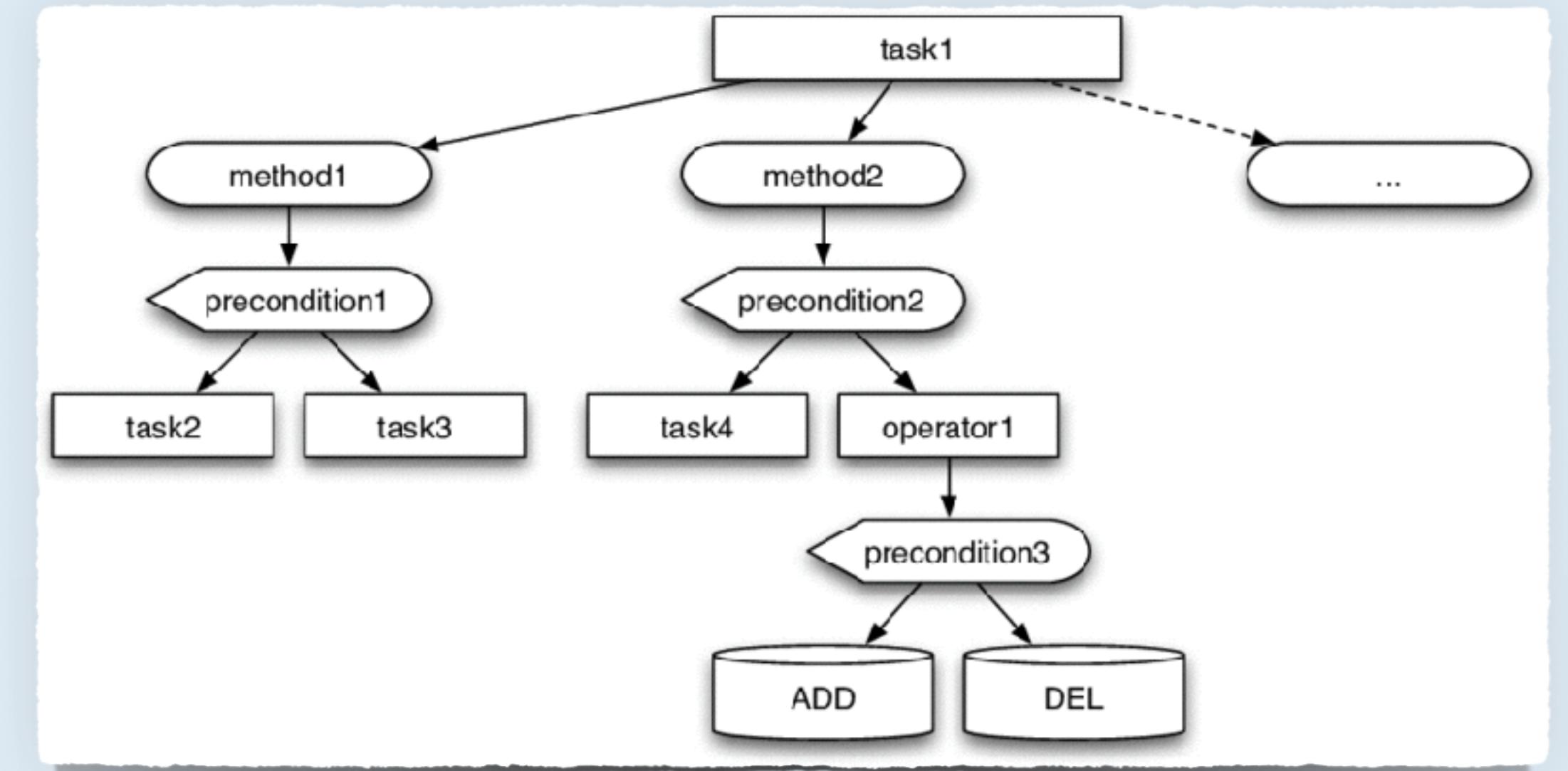
- Search in the space of **plans**
- Arcs represent *refinement operations* (**fixes**) in presence of **flaws**
- Modeling trick:
  - Missing phenomenon is a **flaw**
  - Narratively correct structure is a **fix**
- Originally used for adding character *intention*



# Hierarchical Task Network Planning

## Modeling Narrative Phenomena in Terms of **Re-write Rules**

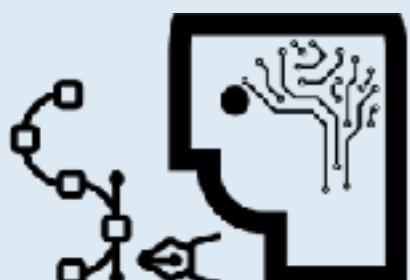
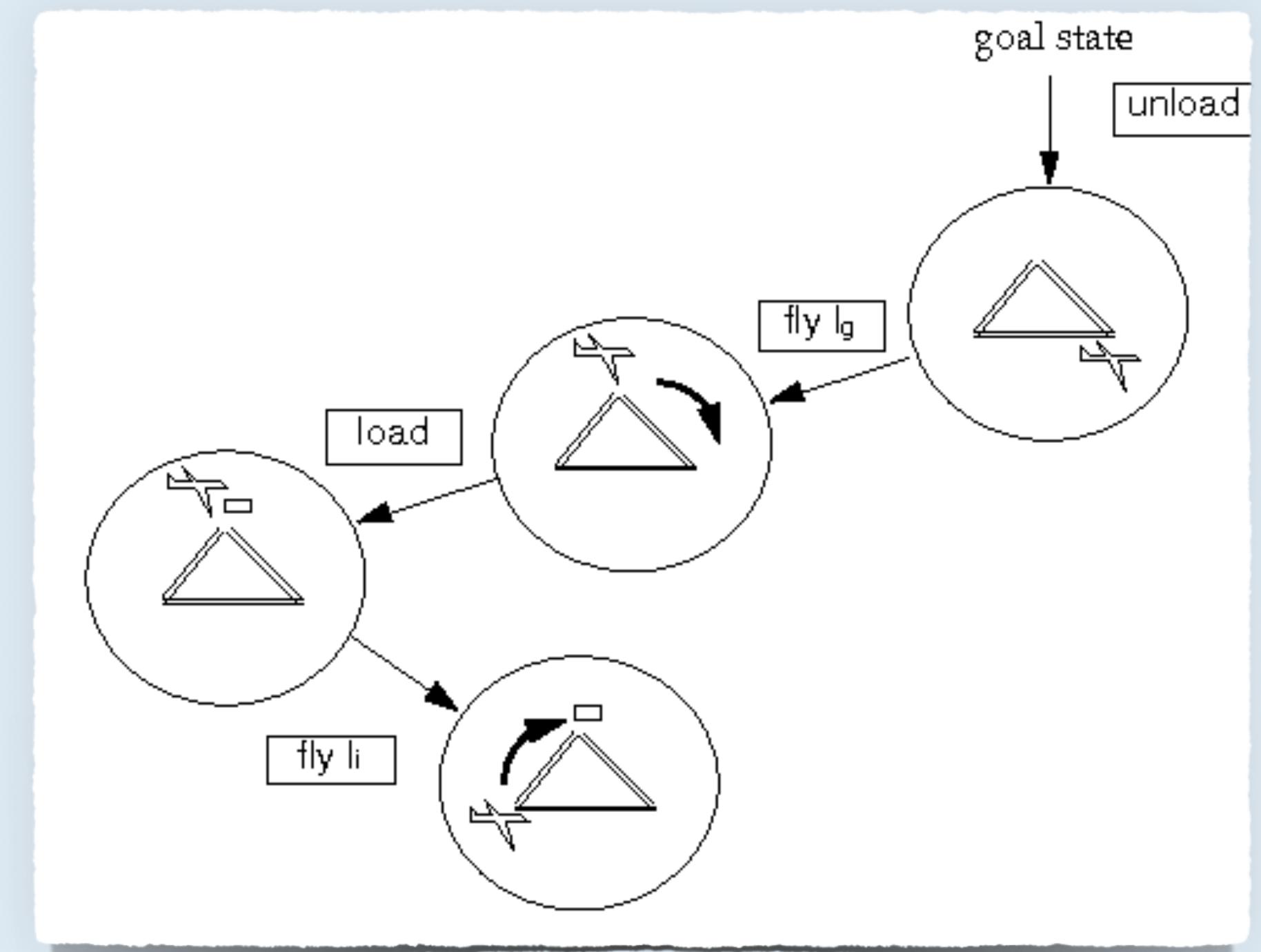
- Search in the space of **tasks** and **decompositions**
- Modeling trick:
  - Phenomenon is describable in terms of abstractions over elements
  - Narratively correct structure is the full expanded network
- Can also be used for adding character *intention*



# Heuristic Search State-based Planning

## Modeling Narrative Phenomena in Terms of Guidance

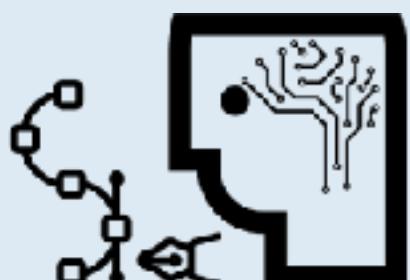
- Search in the space of **states** and **codified preference for them**
- Modeling trick:
  - Phenomenon is describable in terms of states you need to achieve
  - Narratively correct structure is the synthesized plans
- Can also be used for adding character *intention* (e.g. Glaive)



# You will understand narrative planning aims, themes, and methods

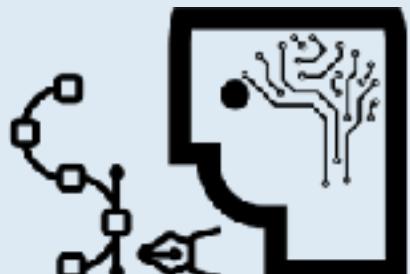
## Recap

- The Classical Basis: Re-interpreting Familiar Ingredients
- The Different Layers of Narrative: A Story “MVC” – Plot, Discourse, Narration
- The Different Modeling Methods: PSP, HTN, HSP

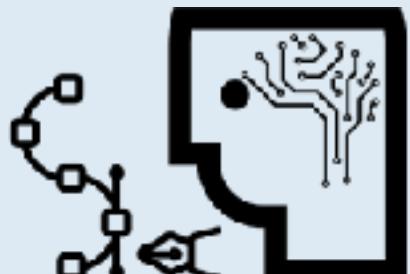


# Unique Narrative Planning Challenges

# Case: *Intention* and *Conflict*



Why does *intention* and  
*conflict* matter?



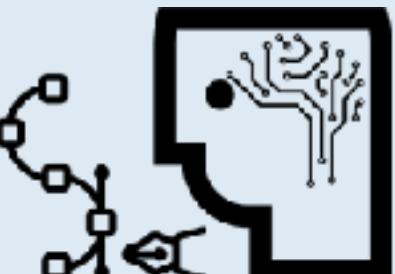
# Plot Planning in GLAIVE

## Actions v. Happenings

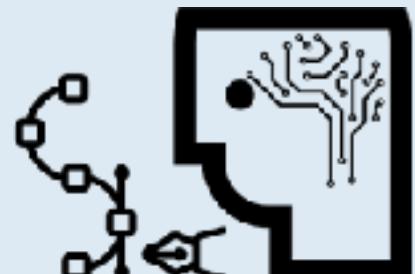
- Expanded KR:
  - ▶ The **intends** modal predicate: (**intends** indiana (**alive** indiana))
  - ▶ Consenting agents in *actions*:

```
(:action eliminate
  :parameters (?attacker - character ?w - weapon
               ?target - character ?p - place)
  :precondition (and (alive ?attacker) (alive ?target) (has ?attacker ?w)
                      (at ?attacker ?p) (at ?target ?p))
  :effect (not (alive ?target))
  :agents (?attacker))
```

- No right or wrong way to make characters more believable



**Return to  
The Ark Domain  
Code**



# Narrative Domains & Expressive Range

# Glaive

[cs.uky.edu/~sgware/projects/glaive/](http://cs.uky.edu/~sgware/projects/glaive/)

- Requires **Java 7**
- Available as a (Java) .jar
- Includes several narrative domains
  - ▶ Aladdin, Ark, Fantasy, Heist, Space, Western
- I will use it in all acts of my tutorial presentations



## Previously...

Proceedings of the Tenth Annual AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment (AIIDE 2014)

### Glaive: A State-Space Narrative Planner Supporting Intentionality and Conflict

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Ware, S., & Young, R. M. (2014). Glaive: A State-Space Narrative Planner Supporting Intentionality and Conflict. In Proceedings of the 10th AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment (pp. 80-86).



# Glaive

[cs.uky.edu/~sgware/projects/glaive/](http://cs.uky.edu/~sgware/projects/glaive/)

- Requires **Java 7**
- Available as a (Java) .jar
- Includes several narrative domains

- ▶ Aladdin, Ark, Fantasy, Heist, Space, Western

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## Glaive: A State-Space Narrative Planner Supporting Intentionality and Conflict

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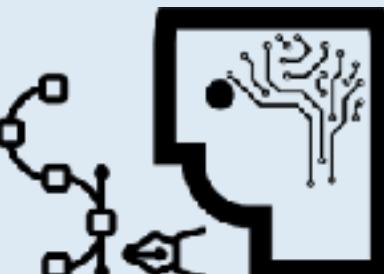
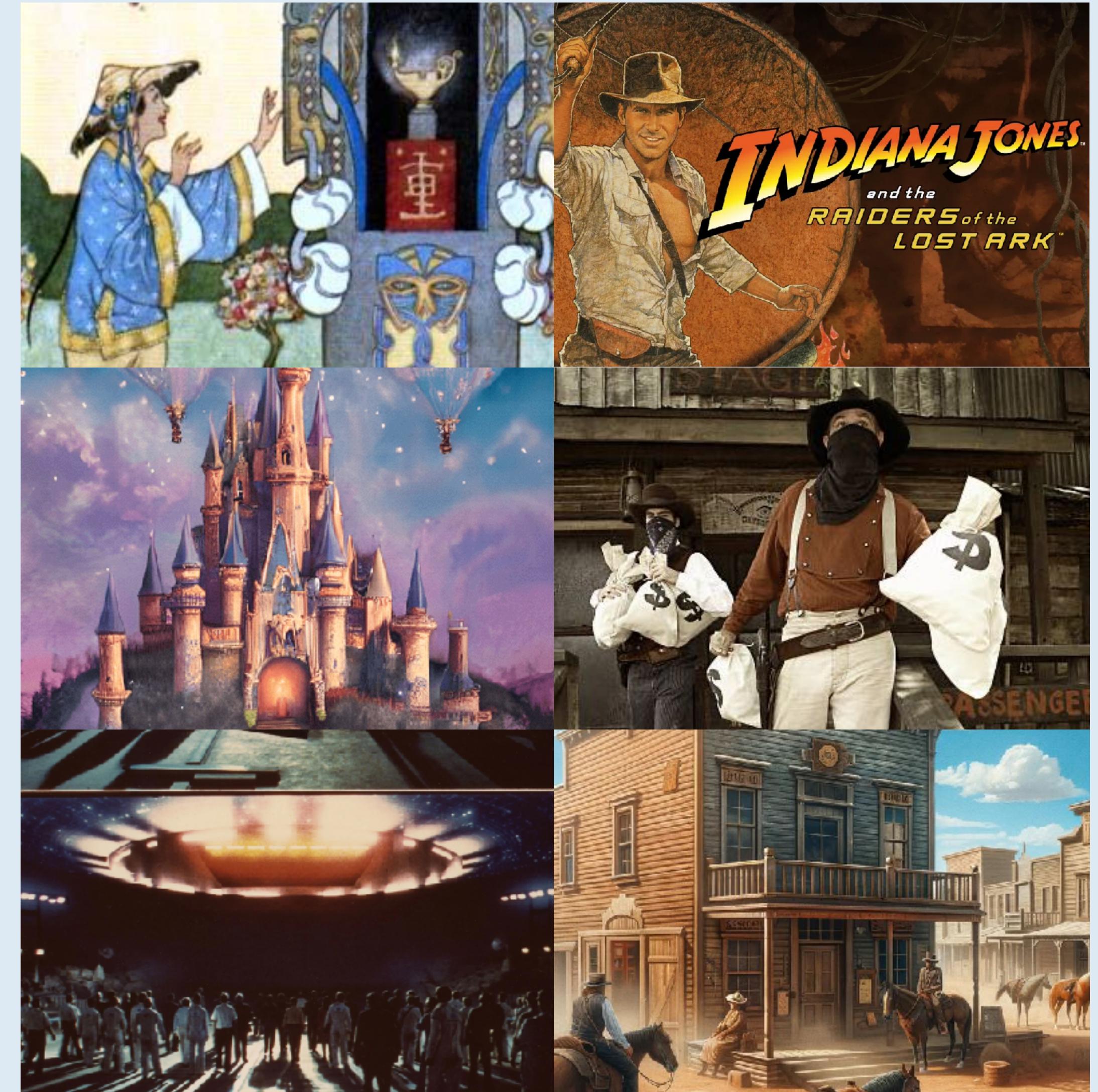
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# A tour through Narrative Benchmark Domains

The Aladdin, Ark, Fantasy,  
Heist, Space, and Western  
Virtual Worlds

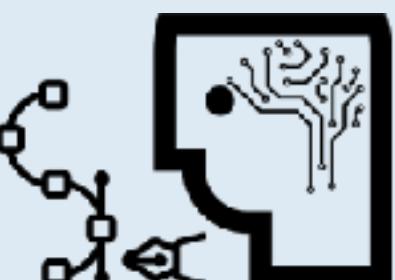


# **Narrative Domains and Expressive Range**

## **The Generative Space of Possible Stories**

- Each domain has its own narrative potential
- Part of the narrative planning paradigm is to answer the question:

**To what degree does my narrative planner accomplish my modeling goal(s)?**





# Recap

- **Act I: From Classical to Narrative Planning** (30 minutes)
- **Act II: Unique Narrative Planning Facets** (30 minutes)
  - ▶ Coffee Break! (30 minutes)
- **Act III: Narrative Domains & Expressive Range** (30 minutes)

