

## Setting up the presentation:

- This presentation uses videos that start by clicking on the respecting picture.
- Not every PDF viewer is capable handling embedded videos. On Linux, Okular can do that.
- These videos are contained in this zip. Make sure they remain in a folder named “movies” that is next to this presentation.



# Plan, Repair, Execute, Explain

How Planning Helps to Assemble your Home Theater

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Provide advanced user assistance based on:

- *user-centered* planning:  
plan generation, execution, repair, explanation
- user interaction:  
dialog and interaction management

Example domain:

- set up a complex home theater



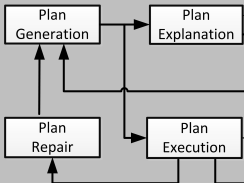


## The Assembly Task:

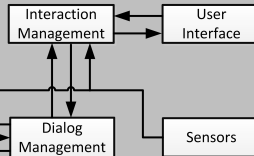




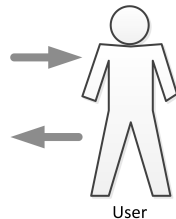
## Planning Environment



## User Interaction



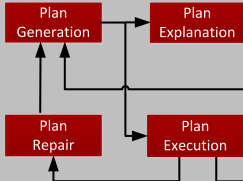
Knowledge Base



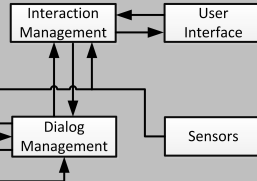
User



## Planning Environment

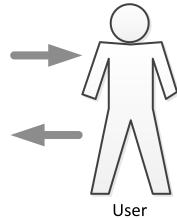


## User Interaction



Knowledge Base

Sensors



User

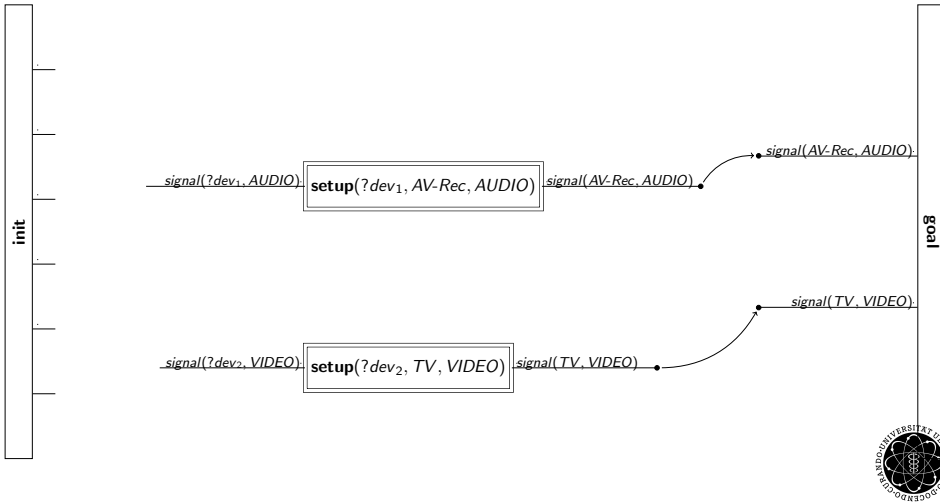


*Hybrid Planning:*

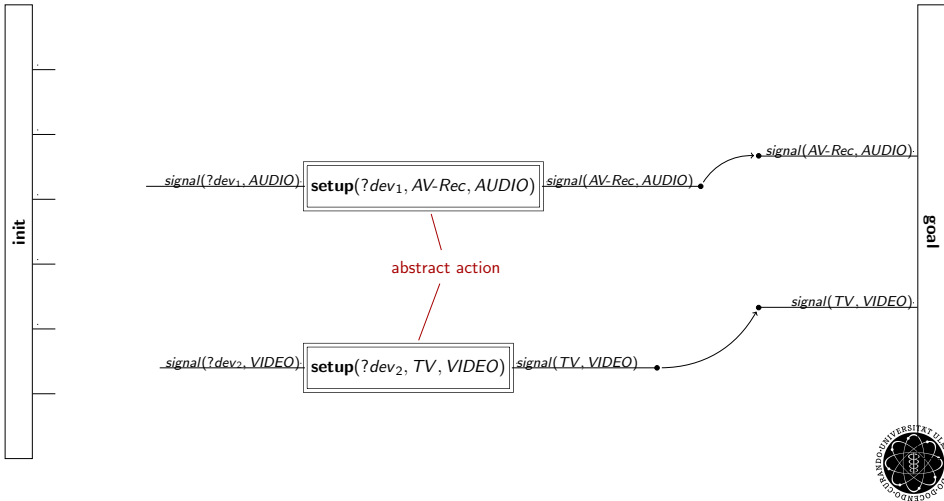
- approach fusing Hierarchical Task Network (HTN) Planning with Partial-Order Causal-Link (POCL) Planning
- search in the space of partial plans
- refine the initial partial plan until it is executable



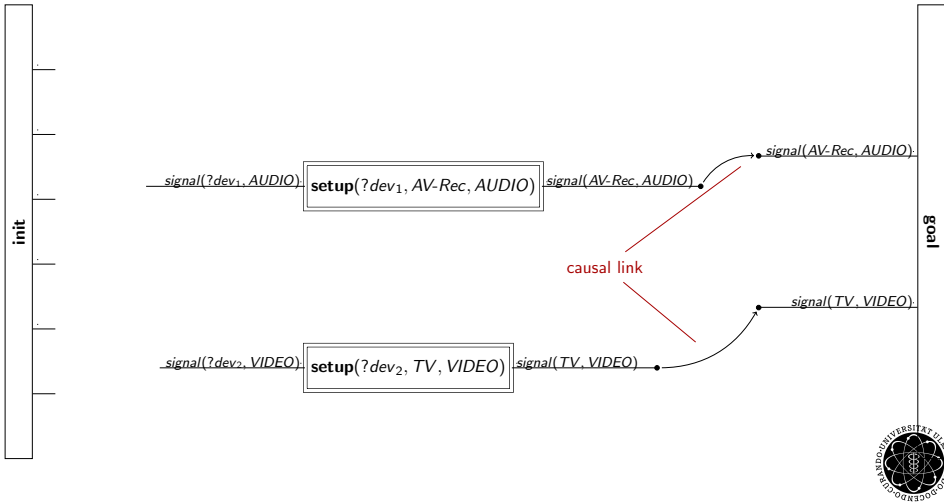




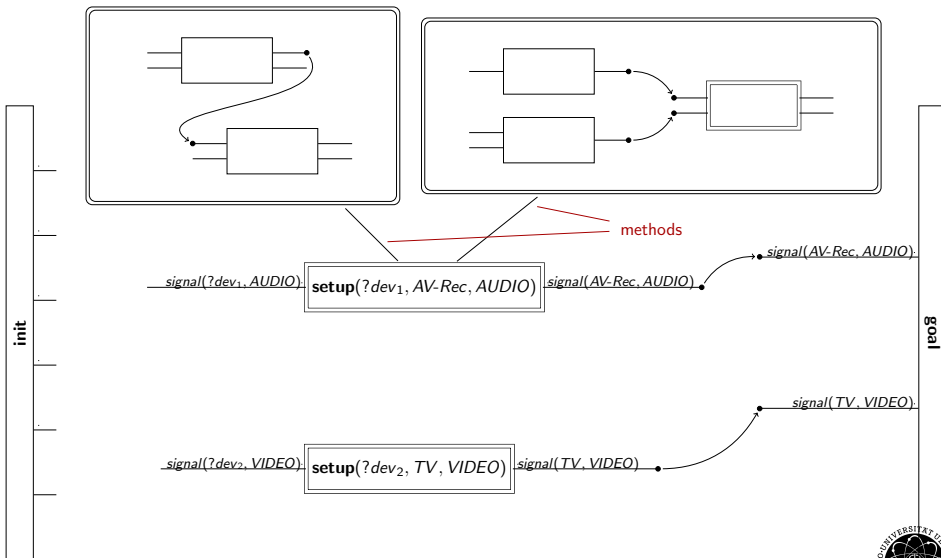




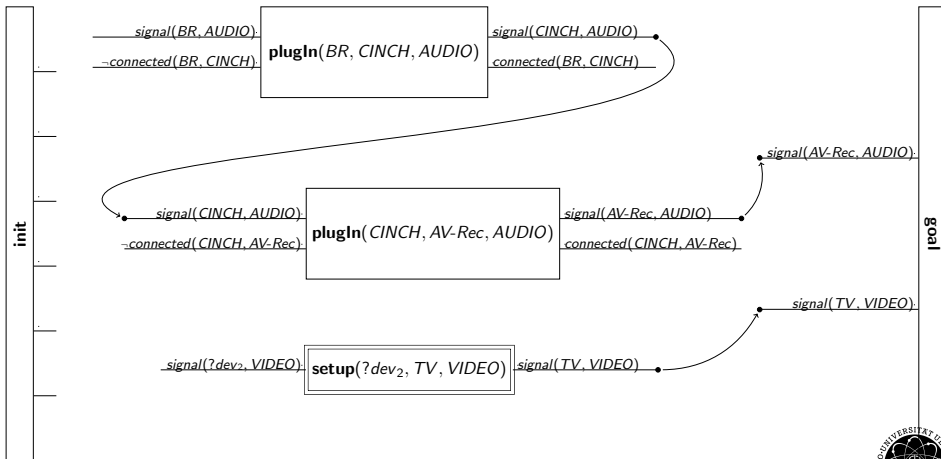




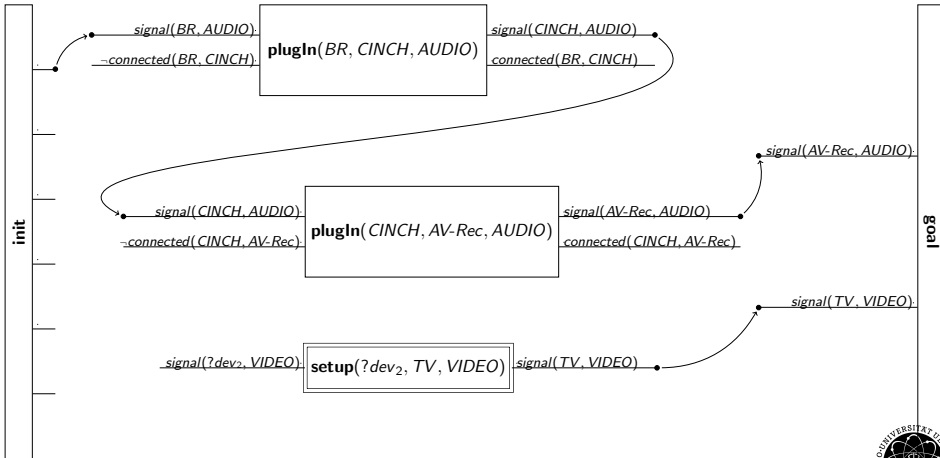




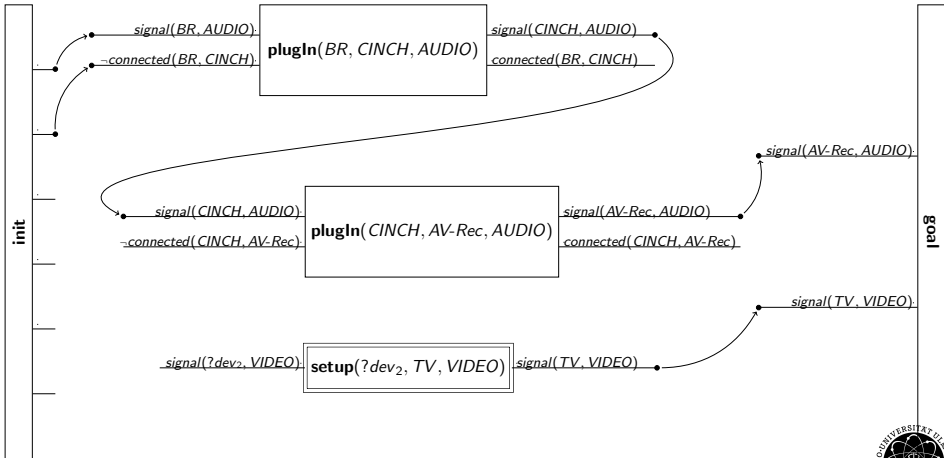




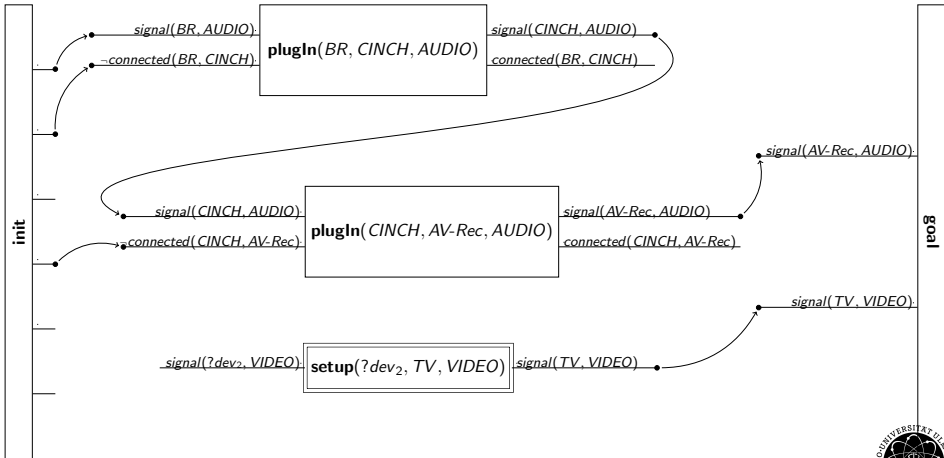




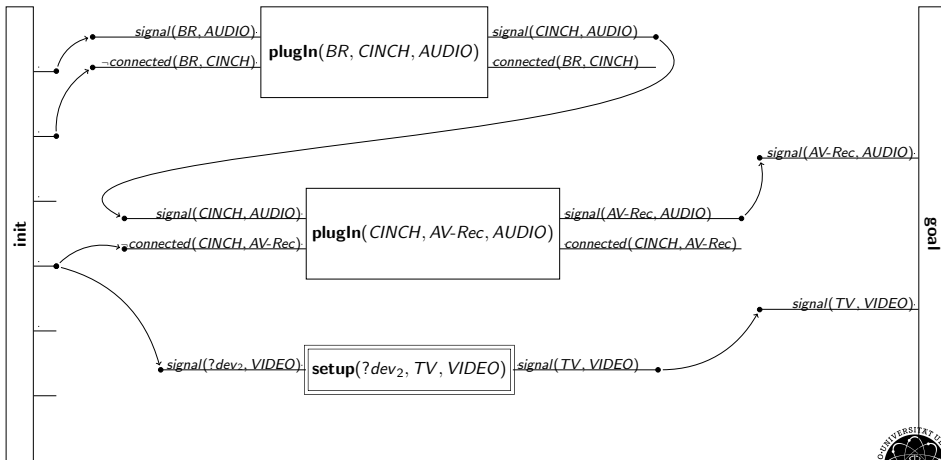




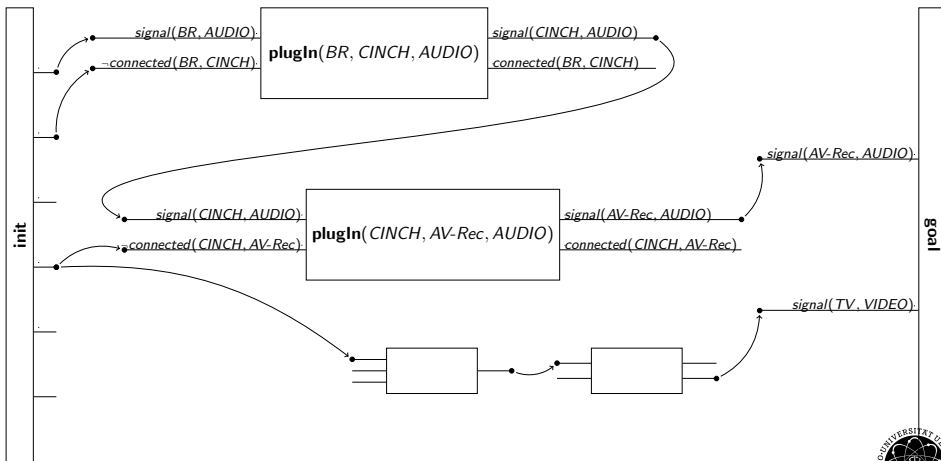




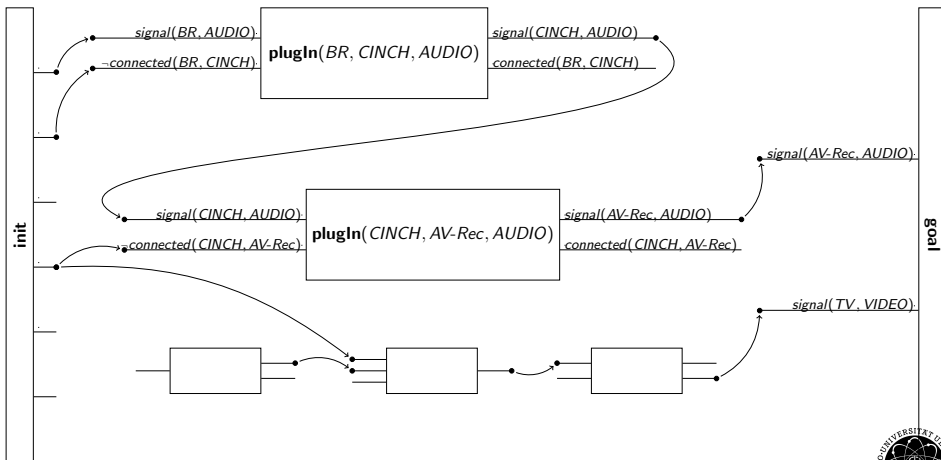




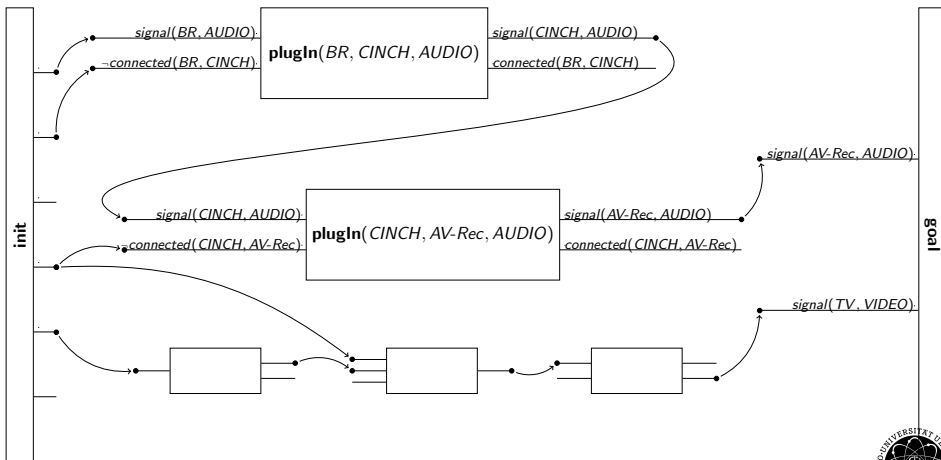




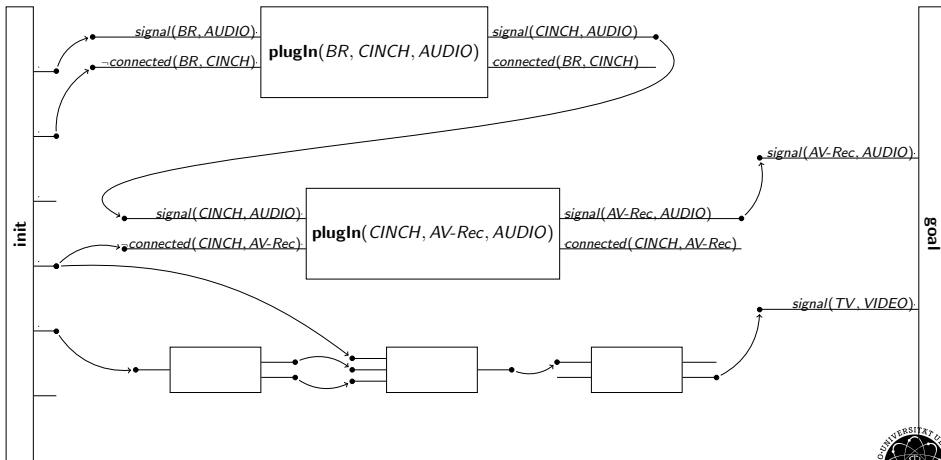




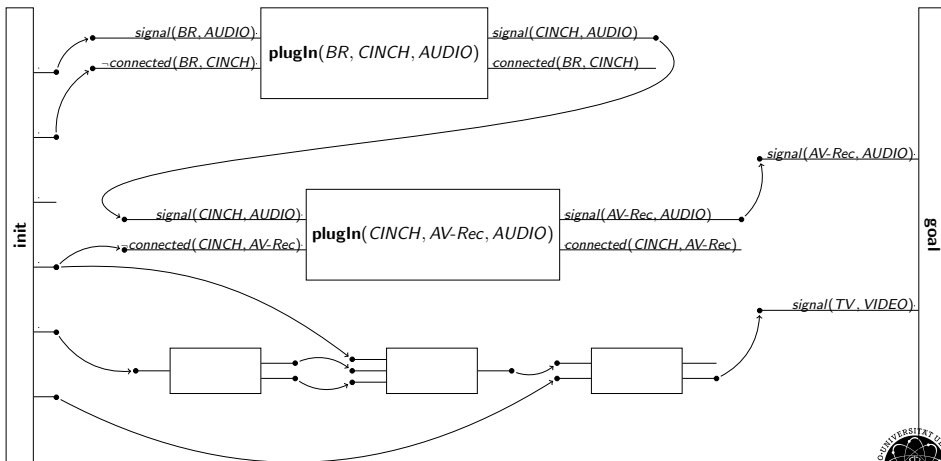








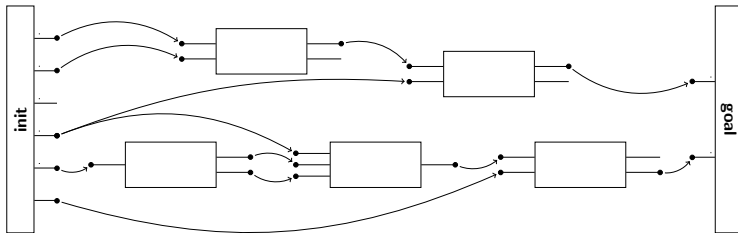






communicate solution plan to the user:

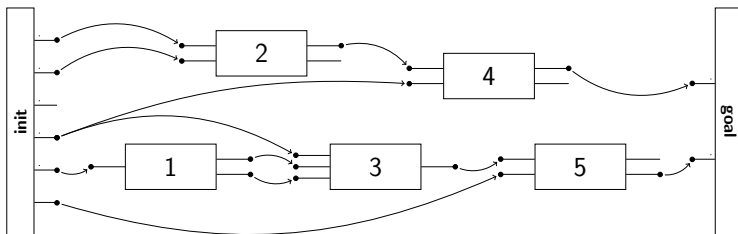
- generate a plausible linearization of the actions





communicate solution plan to the user:

- generate a plausible linearization of the actions

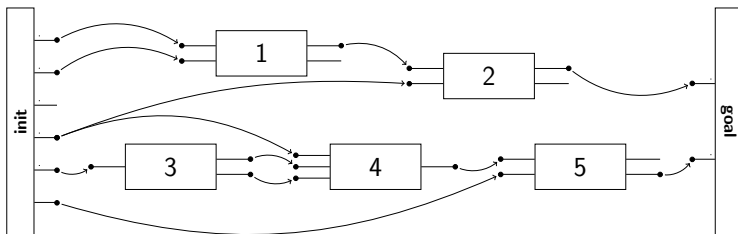


- 1: connect ...
- 2: connect CINCH cable (the first end) with Blu-ray player
- 3: connect ...
- 4: connect CINCH cable (the other end) with AV receiver
- 5: connect ...



communicate solution plan to the user:

- generate a plausible linearization of the actions

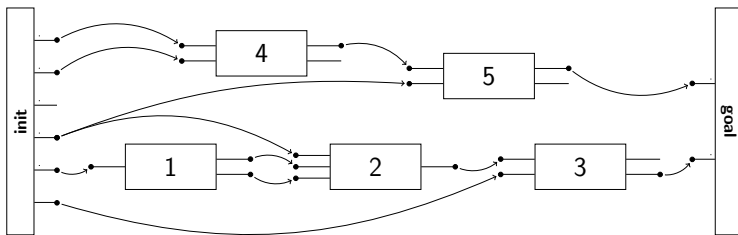


- 1: connect CINCH cable (the first end) with Blu-ray player
- 2: connect CINCH cable (the other end) with AV receiver
- 3: connect ...
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communicate solution plan to the user:

- generate a plausible linearization of the actions

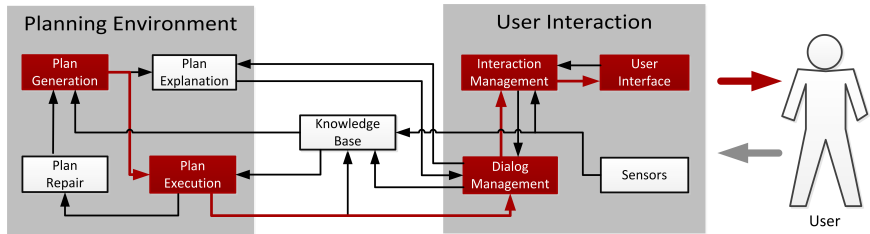


- 1: connect ...
- 2: connect ...
- 3: connect ...
- 4: connect CINCH cable (the first end) with Blu-ray player
- 5: connect CINCH cable (the other end) with AV receiver



communicate solution plan to the user:

- present the solution plan action by action
- display each primitive action in an adequate manner
  - load dialog model for each action
  - display dialog according to interaction management









Plan execution fails if:

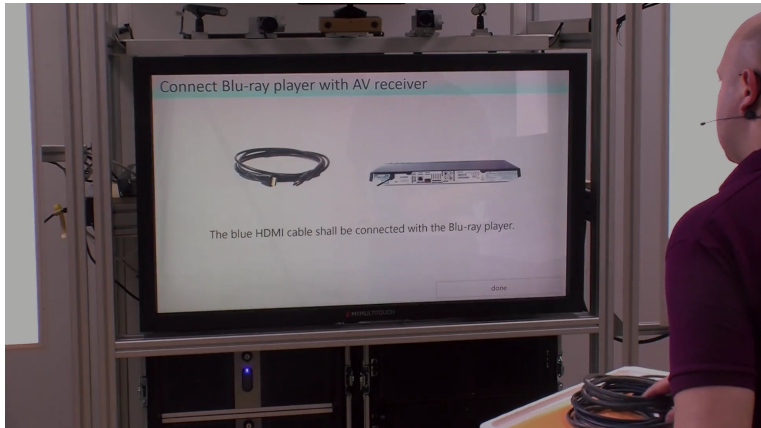
- current world state differs from expected world state
- in our example:  $broken(HDMI)$  vs.  $\neg broken(HDMI)$

Repair procedure:

- already executed actions must occur in new solution
- unexpected state changes are represented by an ad-hoc generated additional action (so-called process)









**Question:** Why is that action necessary for my task?

Explanations in natural language are generated from (raw) proofs in an axiomatic system based on:

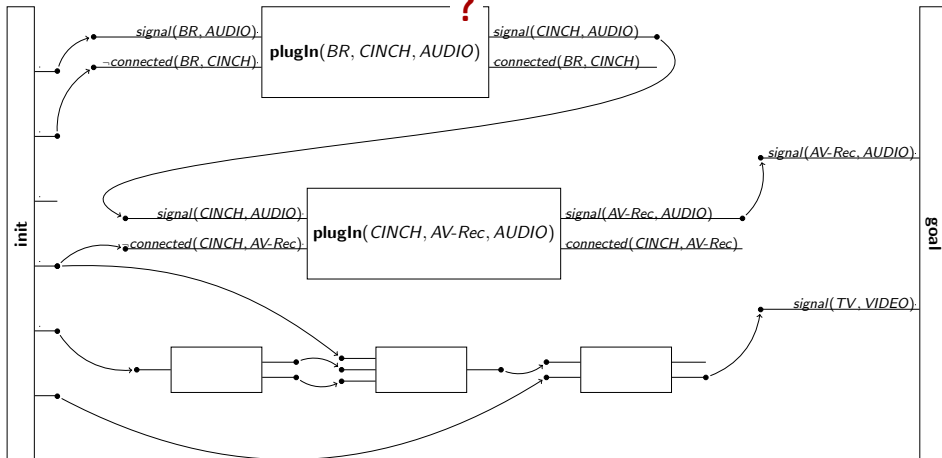
- the solution plan's causal structure (causal links)
- the decomposition hierarchy

Example axioms:

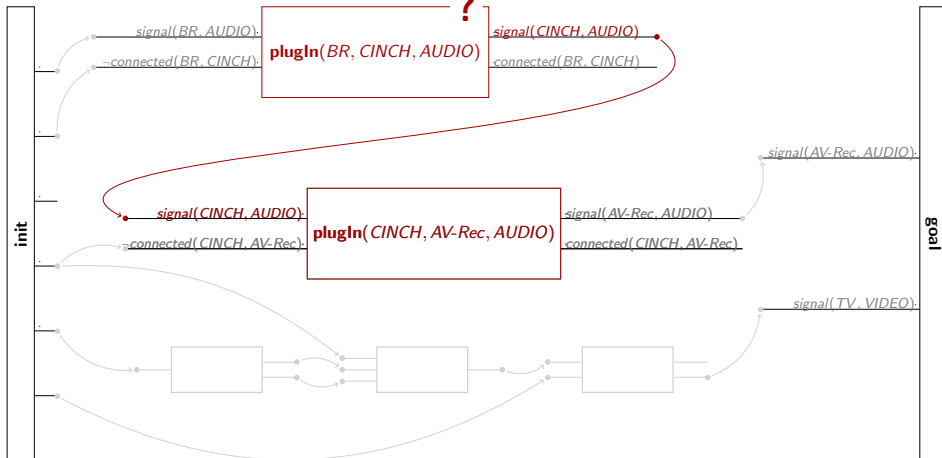
- $\forall \text{ actions } a_1, a_2 : CR(a_1, a_2) \wedge N(a_2) \Rightarrow N(a_1)$
- $N(\text{goal})$





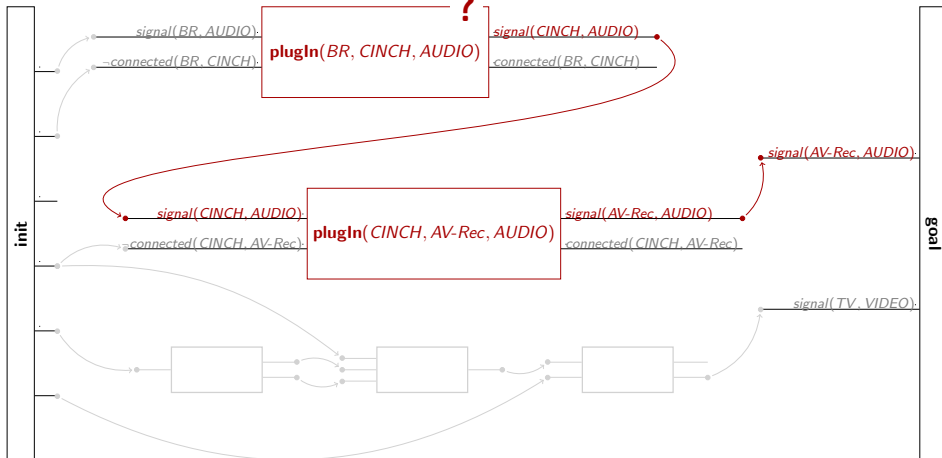






$$\begin{aligned} & CR( \text{plugIn}(BR, CINCH, AUDIO) , \text{plugIn}(CINCH, AV-Rec, AUDIO) ) \wedge \\ & N( \text{plugIn}(CINCH, AV-Rec, AUDIO) ) \\ \Rightarrow & N( \text{plugIn}(BR, CINCH, AUDIO) ) \end{aligned}$$

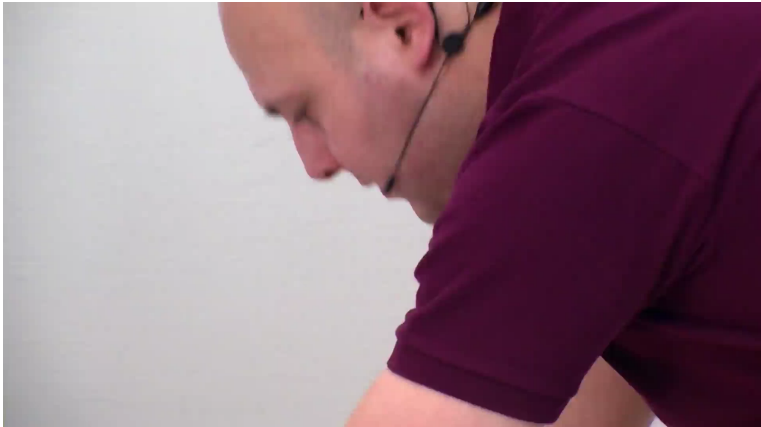


CR( **plugIn**(CINCH, AV-Rec, AUDIO), goal )  $\wedge$   
 N( goal )  
 $\Rightarrow$  N( **plugIn**(CINCH, AV-Rec, AUDIO) )









We evaluated:

- the general acceptance of such an assistance system
- the impact of plan explanation:  
does plan explanation foster the user's confidence in correctness of solution?





- assembly task:
  - television needs video signals
  - AV receiver needs audio signals
- subjects were given a solution plan on an iPad and asked to follow the instructions
- experiment is designed as controlled, randomized trial with 59 subjects in two groups
  - treatment group was presented a plan explanation for two fixed actions
  - control group only received that instruction





## Hypothesis:

- subjects were asked to rate their confidence that the presented solution plan is correct, i.e., solves the task
- mean/sd confidence on a 5-point Likert scale:  
4.50/0.82 (treatment), 4.66/0.55 (control)  
(the difference is not statistically significant)
- confidence was already very high





## General findings:

- device and port photographs often mentioned positively
- high correlation between the overall perception and the self-rated skills (people considering themselves unskilled liked the system better)
- women liked the system better than men
- people with higher educational level liked the explanation better





Some positive remarks by subjects:

- “assists in a useful way”
- “this assistant would be great for my parents”
- “the explanations seem to be unnecessary at first glance, but they increase the understanding of what one does and strengthen the credibility of the system”





## Main Results:

- developed architecture providing user assistance
- it integrates *user-centered* planning capabilities:  
plan generation, execution, repair, explanation
- it integrates planning with user interaction
- user study shows acceptance and usefulness of intelligent user assistance

Video available at <http://www.sfb-trr-62.de/>





### Subjects of empirical user study:

- $\leq 30$  years: 19 female, 27 male
- $\geq 30$  years: 3 female, 7 male
- (age not reported for three subjects)
- 26 subjects had university degree, 9 were doing their Ph.D
- 7 subjects' degree was less than high school
- 30 subjects had technical or mathematical background:  
computer science/engineering, natural science, mathematics