

Making Systems Sensitive to the User's Time and Working Memory Constraints

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Project "Resource-Adaptive Dialog"



DFG Collaborative Research Center
on Resource-Adaptive Cognitive Processes
SFB 378

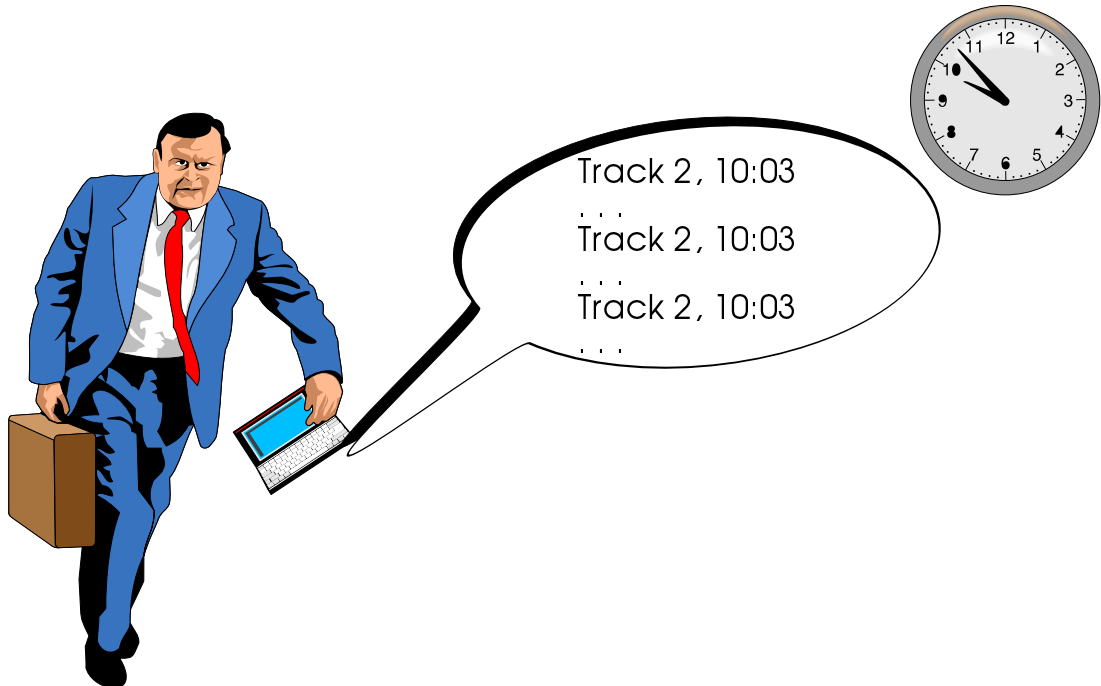
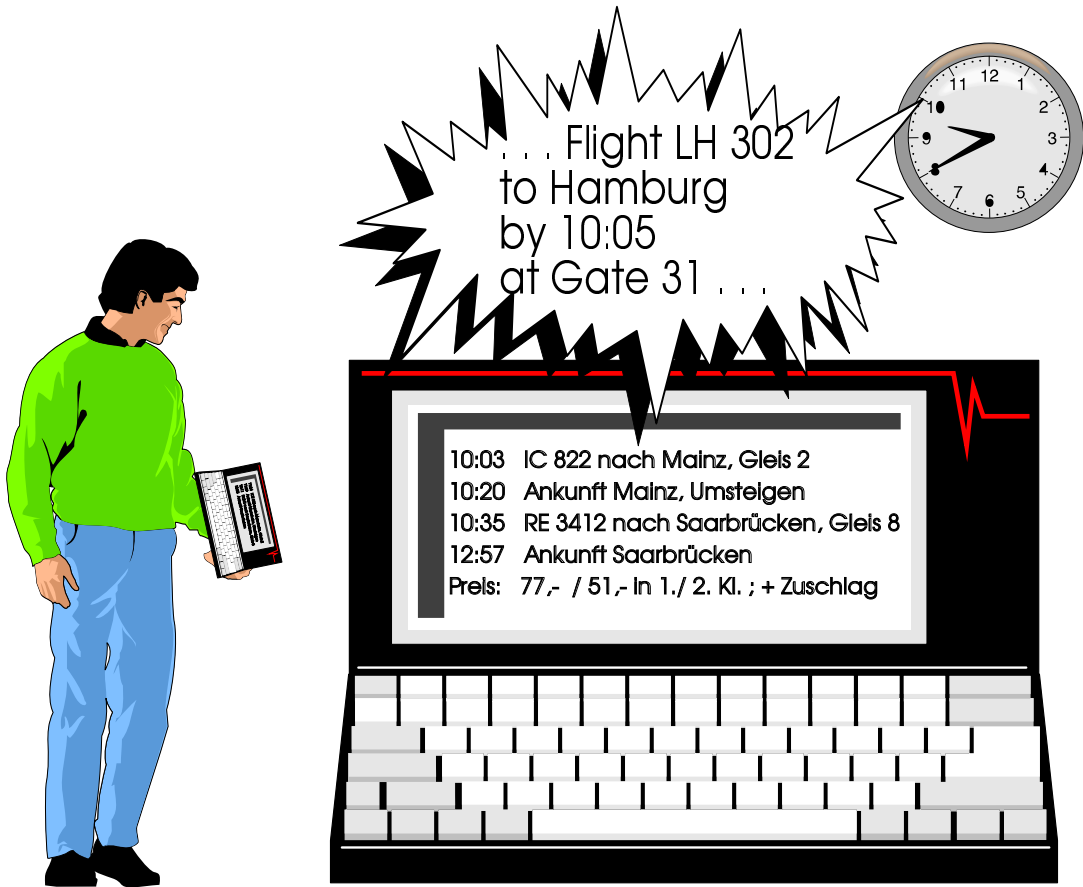
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1. Why is this an important problem?
2. Can we start with a simple, 80/20 solution?
3. How can a more complex, theoretically oriented solution look?
 - Avoiding speech recognition and generation
 - Empirical basis
 - Illustrative example dialog
 - The core: A Bayesian causal model
4. What can we conclude from all this?

Late Second Millenium



Early Third Millenium



Possible Simple Approaches

1. When designing, just assume minimal user resources

Problems:

Resources are variable

When resources are there, they should be exploited

2. Let users influence system behaviors

Problems:

Requires familiarity or obstrusiveness

Consumes user resources

3. Allow users to report on the state of their resources

Problems:

Same as for 2

4. Specify simple input-output relationships

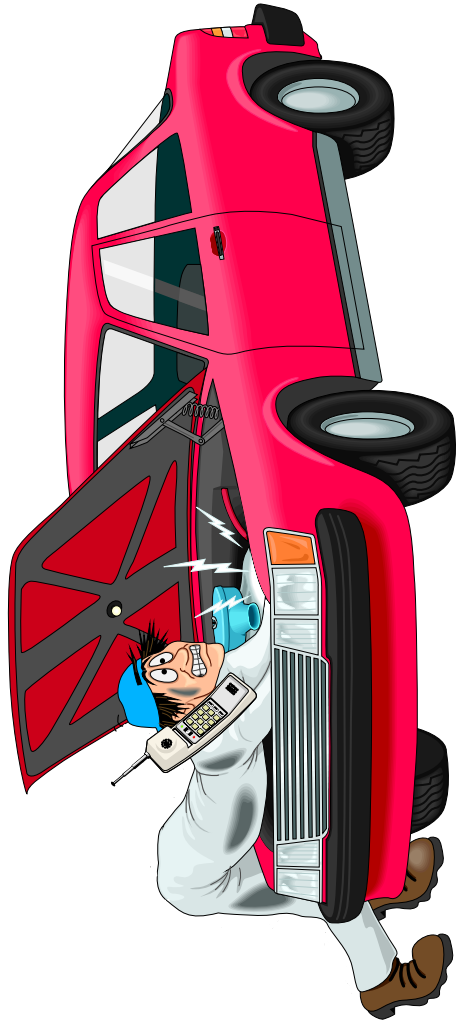
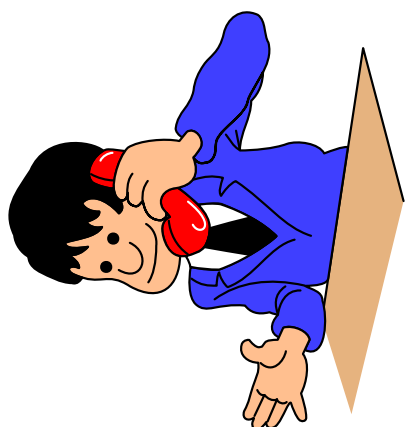
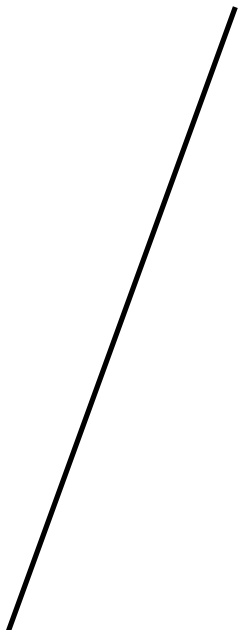
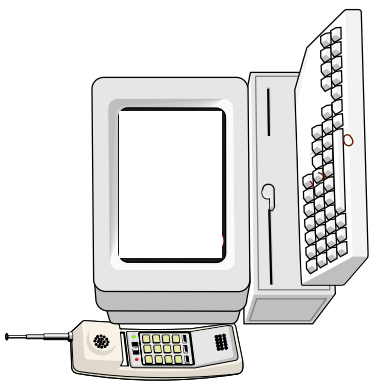
Examples:

1. „If \mathcal{U} talks fast
then \mathcal{S} should synthesize fast speech”
2. „If \mathcal{U} asks for clarification of \mathcal{S} 's output
then \mathcal{S} should simplify subsequent outputs”
3. „. . .”

Problems:

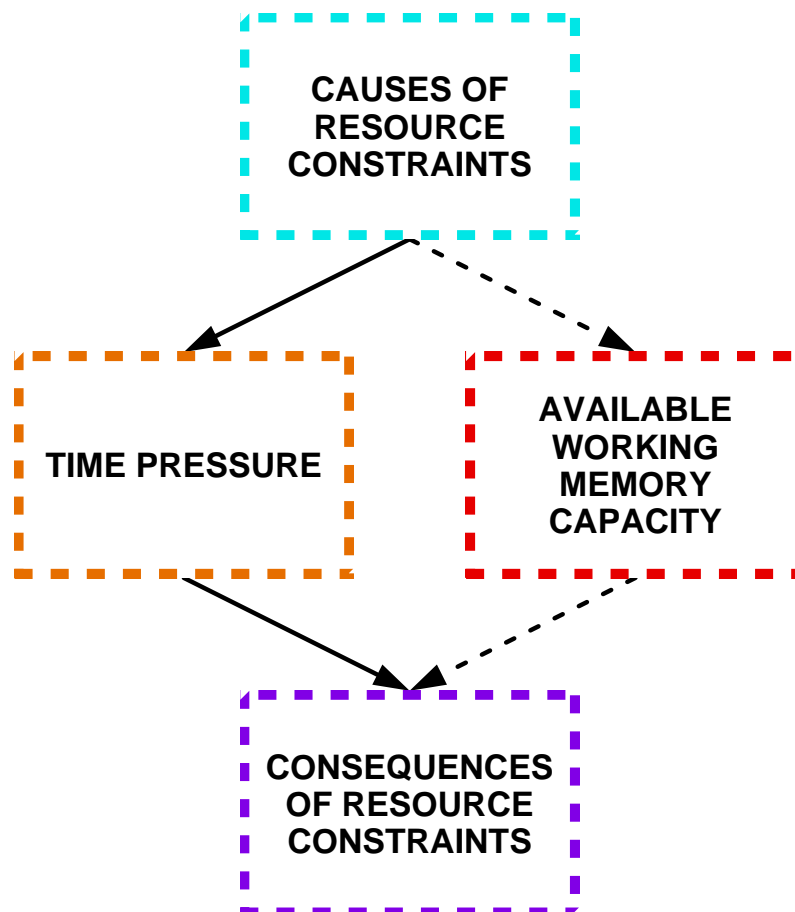
Is Rule N really a good idea? Why? When?

Example Scenario of READY Prototype



Salient Features of the Present Approach

1. Many problems involving input and output techniques are avoided through use of simple simulations.
2. The core of the system is a probabilistic causal model of:



3. The causal model is used for:
 - *Assessing* resource constraints on the basis of observations
 - *Evaluating* possible system actions

Empirical Basis

1. Previous laboratory research

Result:

Partial quantification of relationships among selected variables in artificial situations

2. New laboratory research

Result:

Similar but more quantitative results, concerning the variables you don't yet know about

3. Quantitative analysis of data from real interactions

Result:

Distribution of observable phenomena in realistic situations

4. Knowledge elicitation from experienced persons (e.g., firemen)

Result:

More or less reliable qualitative opinions about causal relationships

Menu for Simulation of Speech Input

READY User Utterance Selection

◆ 1 Cooling water warning lamp is on.

2 <Um.2> The <:> lamp under <eh> next to
 the meter for the cooling water is lit up red.

Utterance length	medium
Clarity of pronunciation	high
Appropriateness of content	moderate
Amount of unnecessary information	none
Anaphora and ellipsis	moderate
Total length of cognitive pauses	small
Number of cognitive pauses	small
Number of repetitions	small
Number of speech errors	small
Accompanying noises	none
Breathing noises	none

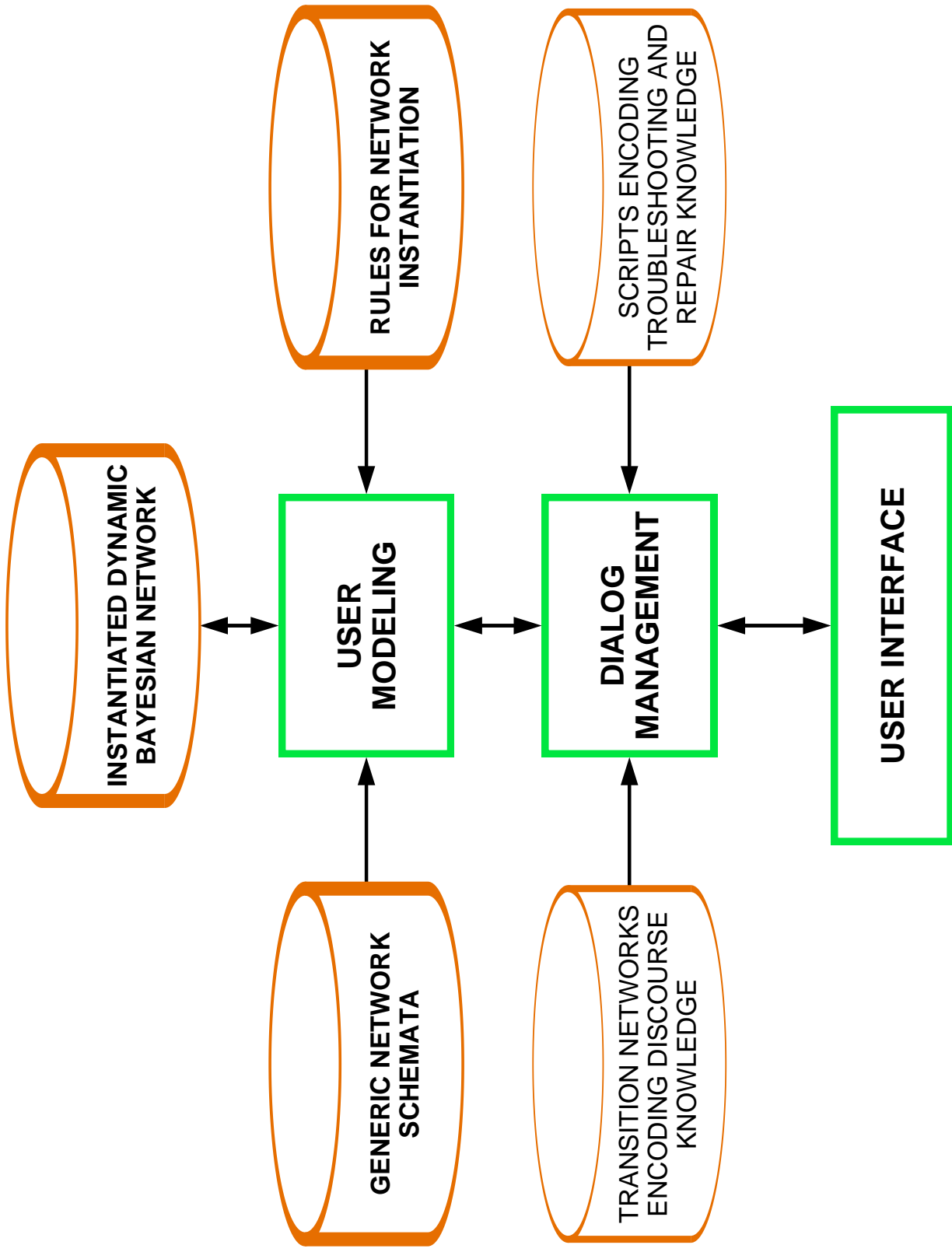
Noises in environment	<input type="text" value="a lot"/>
Speed of articulation	<input type="text" value="high"/>

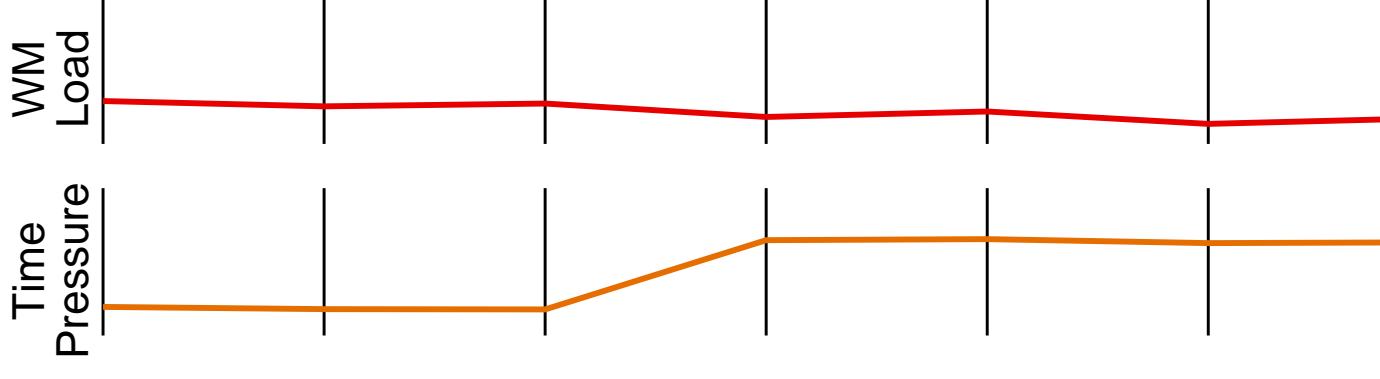
READY's Main Interaction Screen

READY History		
S (2): What type of problem do you have?	<ul style="list-style-type: none"> Speed of articulation: moderate Demands of linguistic analysis on WM: low-moderate (242) Demands of action on WM: low-moderate (346) Success at linguistic analysis: high (848) 	<ul style="list-style-type: none"> AWMC: 692 Time pressure: 328 Knowledge level: 228 Emotional stress: 172
U (2): <no backchanneling>		<ul style="list-style-type: none"> AWMC: 675 Time pressure: 383 Knowledge level: 224 Emotional stress: 175
U (3): Cooling water warning lamp is on.	<ul style="list-style-type: none"> Speed of articulation: high Content quality: moderate Success of conceptualization: moderate (586) 	<ul style="list-style-type: none"> AWMC: 757 Time pressure: 707 Knowledge level: 245 Emotional stress: 66

Backchanneling Utterance End dialog

Coarse View of READY's Architecture





Good morning, automatic repair advice service READY of the SFB378.

S Good morning to you. You are connected to the automatic repair advice service READY of the SFB378.

Joseph Smith here.

U Good day to you, too. This is Joseph Smith from Eckerhausen.

What kind of problem do you have?

S Mr. Smith, how can I help you? Are you having problems with your engine?

Cooling water warning lamp is on.

U Uh ... the lamp ... under, um next to the speedometer for the cooling water is lit up red.

Anything else unusual about the cooling system?

S Have you noticed anything else unusual about the cooling system, maybe steam around the grill at the front of the hood?

The cooler is ... steaming and the fan isn't working.

U At the front of the car - uh, engine, there's, there's something steaming there ... and the fan is off.

U At the front of the car - uh, engine, there's, there's something steaming there ... and the fan is off.

S Under the hood, on the right, in the front, near the yellow oil measuring stick, there's a cable. Please check its plug.

U Cooling water filter ...

U What was that again?

S Under the hood, on the right, in the front, near the yellow oil measuring stick, there's a cable. Please check its plug.

U Plug next to the oil stick.

U What was that again?

S From the plug, there's a cable that goes to the fan. Is the cable damaged somehow - a bit loose or bent?

The cooler is ... steaming and the fan isn't working.

Check the plug on the cooling water filter.

OK.

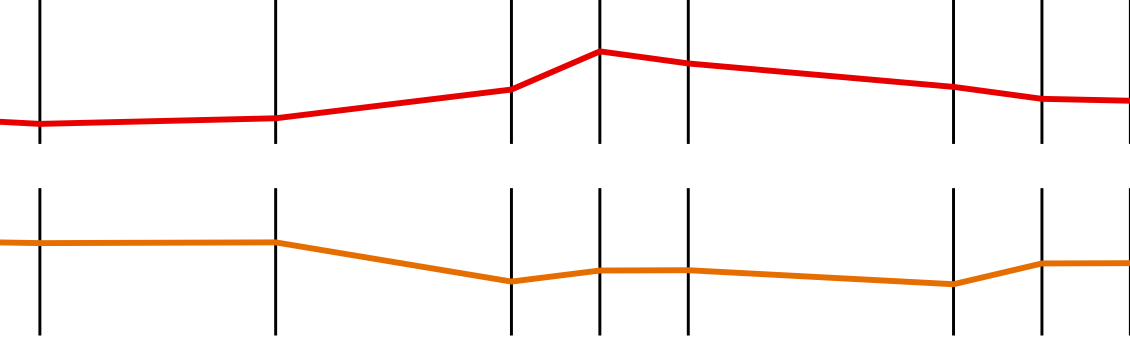
Got it.

Check the plug on the cooling water filter.

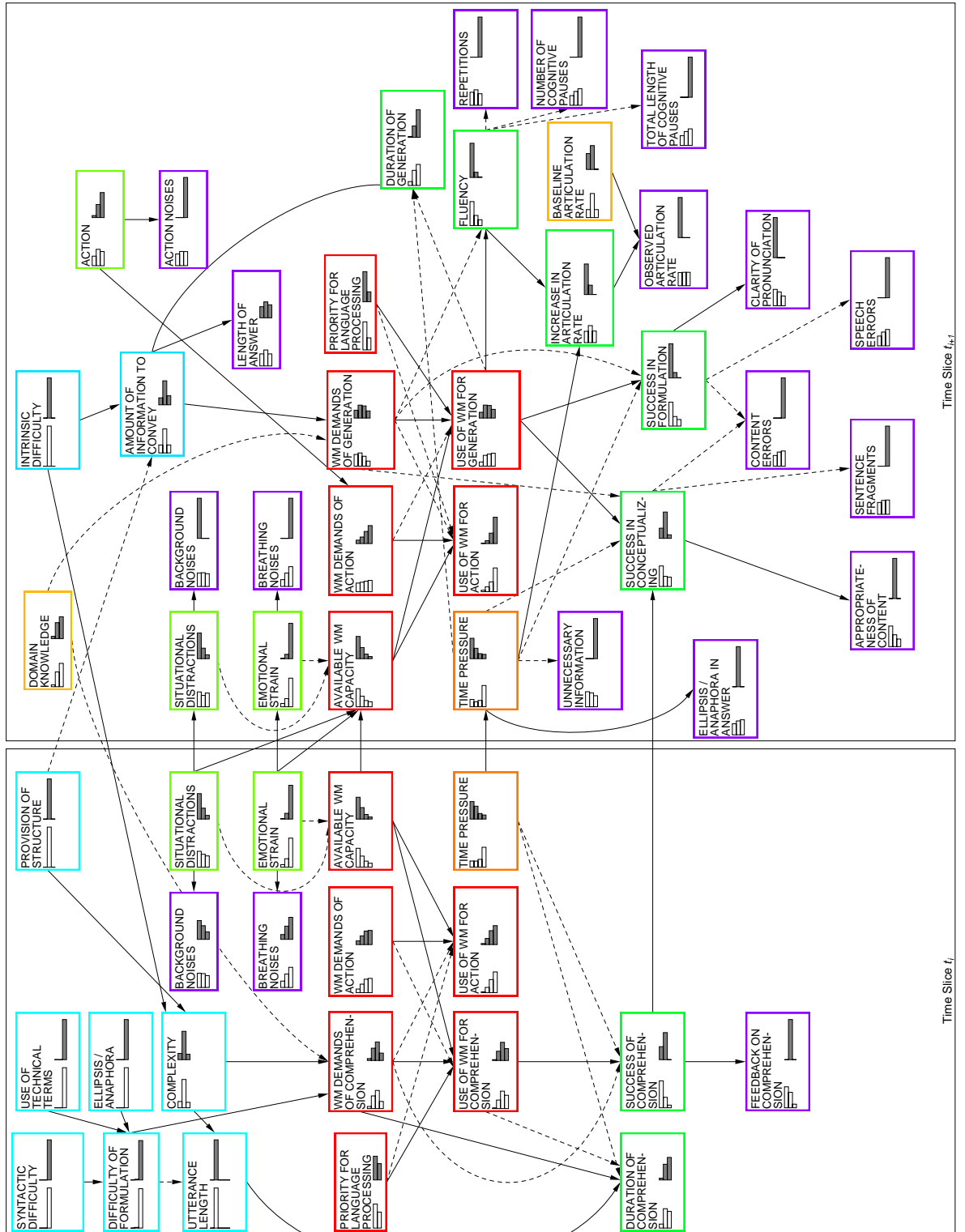
OK.

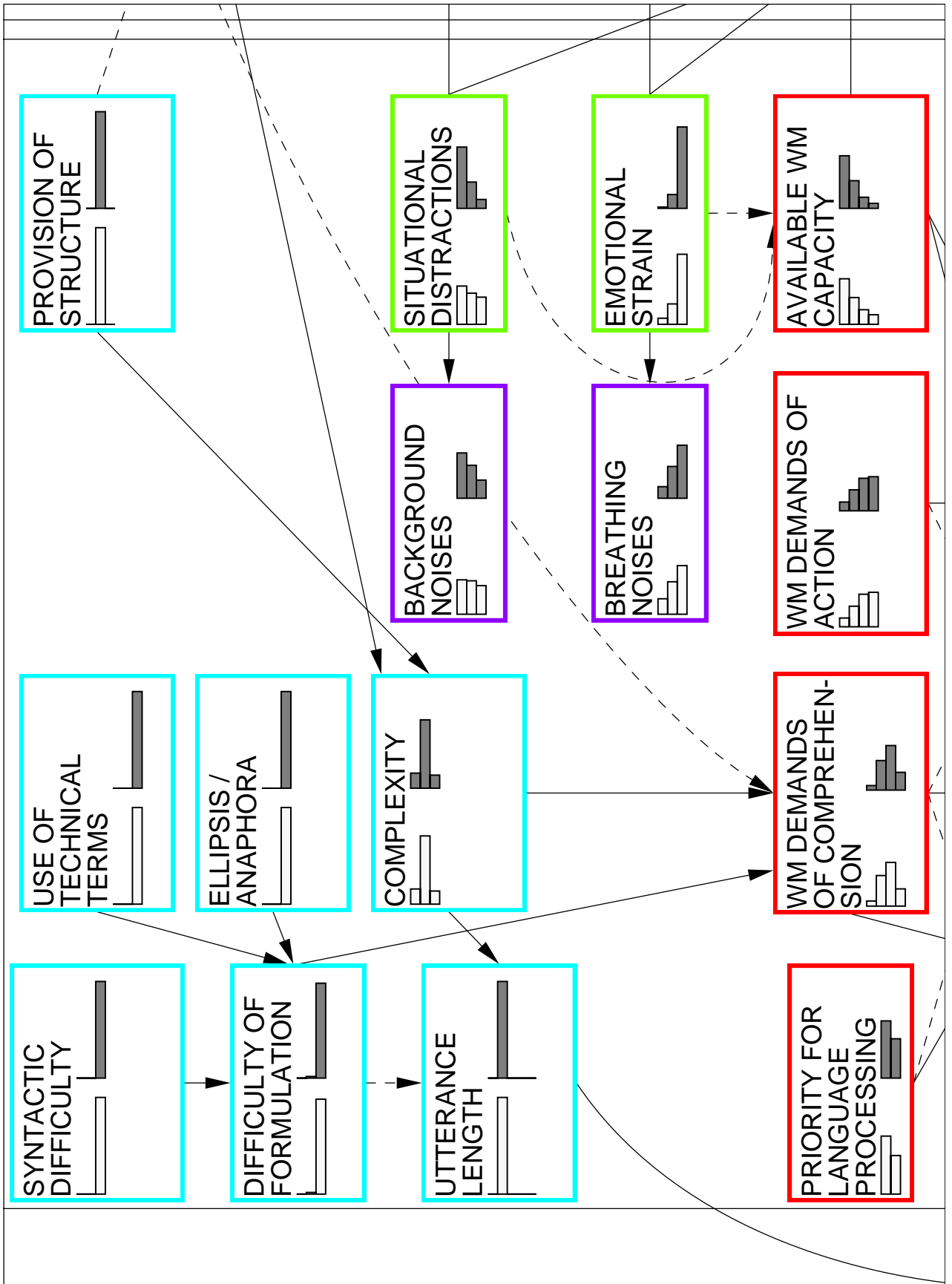
Got it.

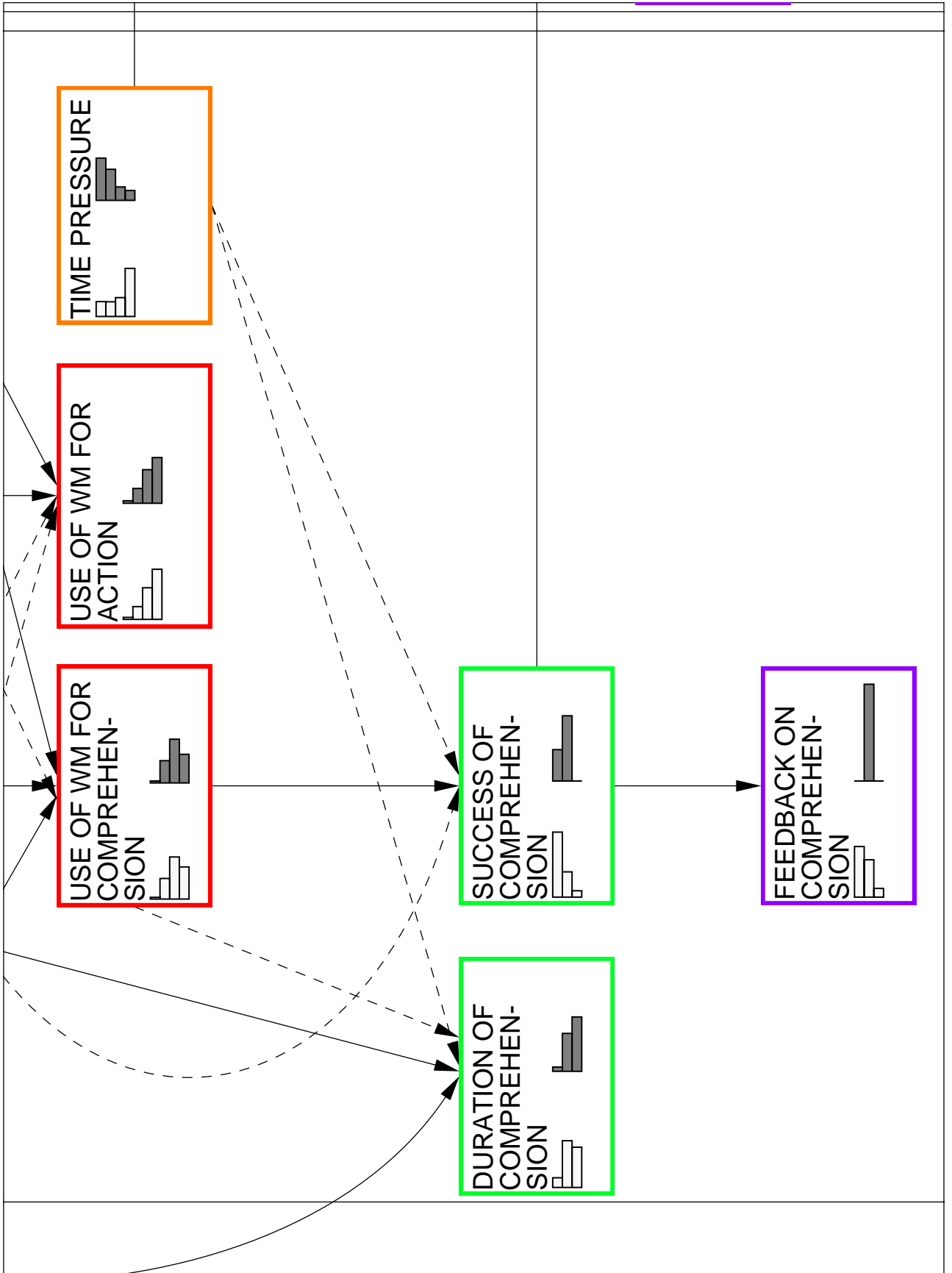
Is the connecting cable damaged?

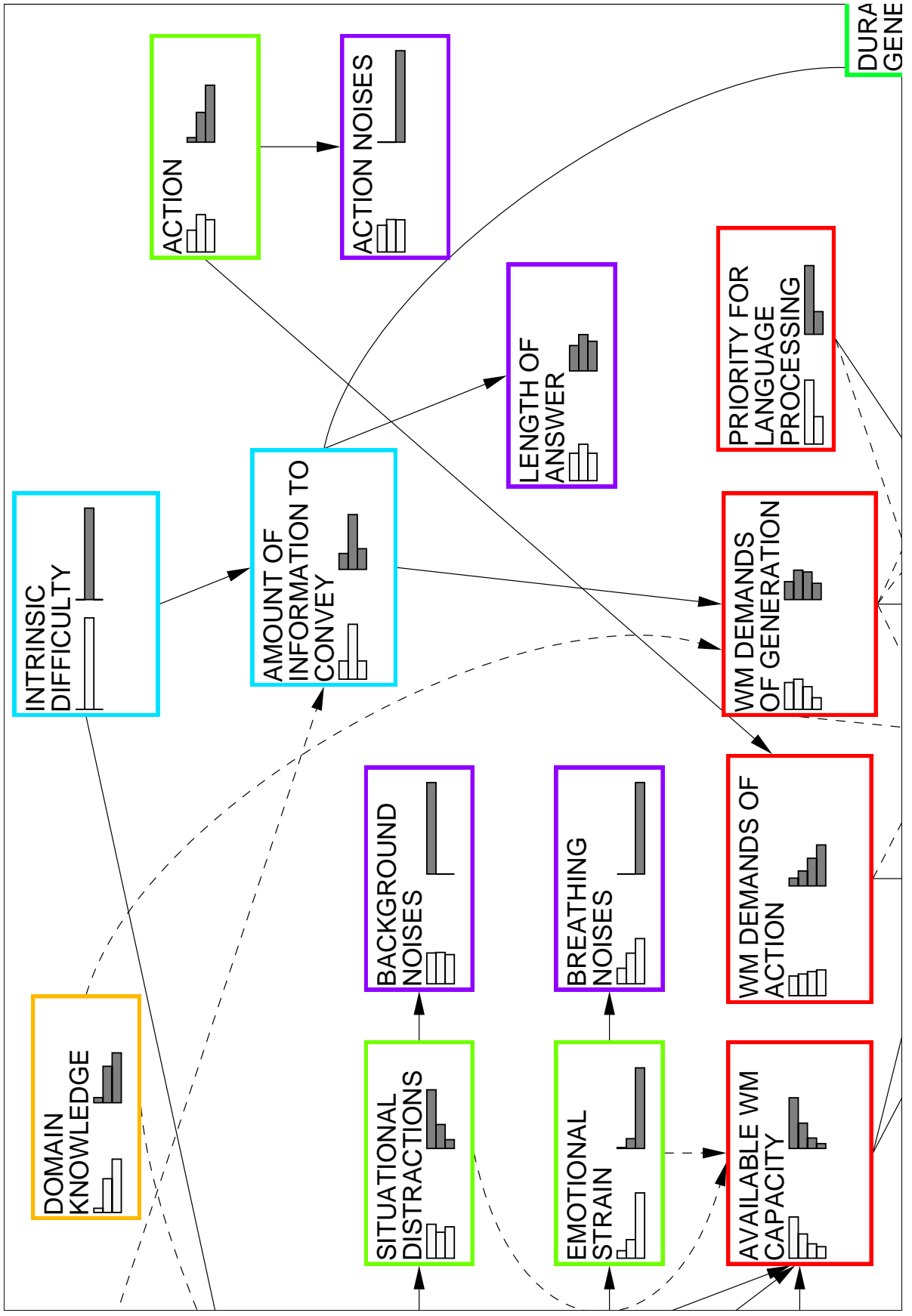


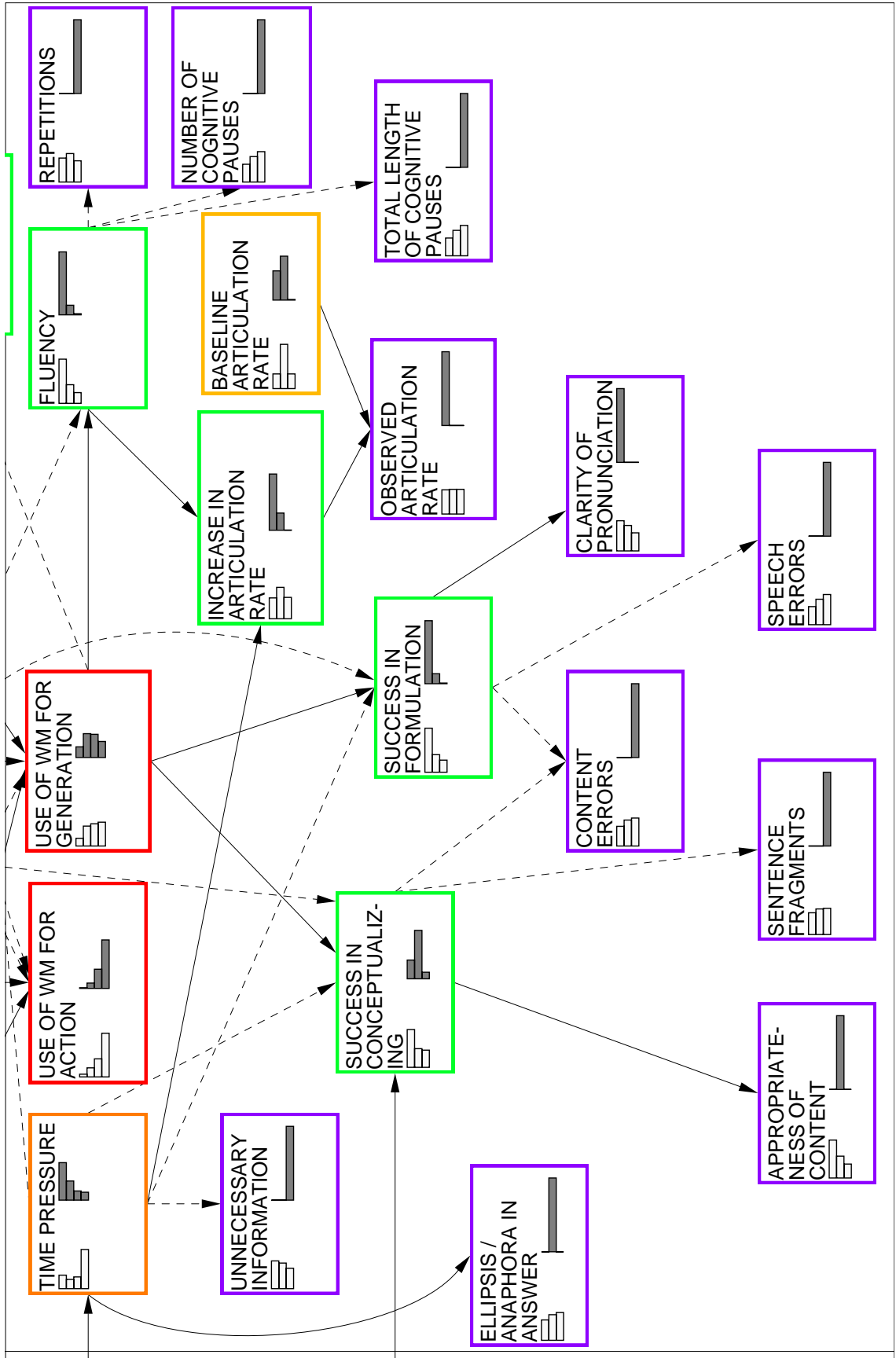
Two Time Slices of a Dynamic Bayesian Net











Conclusions and Future Work

Conclusions

1. In some cases, it is worthwhile to design systems so that they can recognize and adapt to users' changing time and working memory constraints.
2. Some relevant theoretical and empirical results are available, but there is still a lot to be done.
3. An explicit causal model is one useful way of formulating the problem and accumulating knowledge about it:
 - Specific aspects of the model can be based on empirical and theoretical considerations.
 - The system's behavior can be criticized and explained in detail.

Current and future work (selection)

- Generalization to other input and output techniques
- Automatic learning of network probabilities
- Principled choice of 80/20 simplifications