An Application of Rough Sets to Workflow Management

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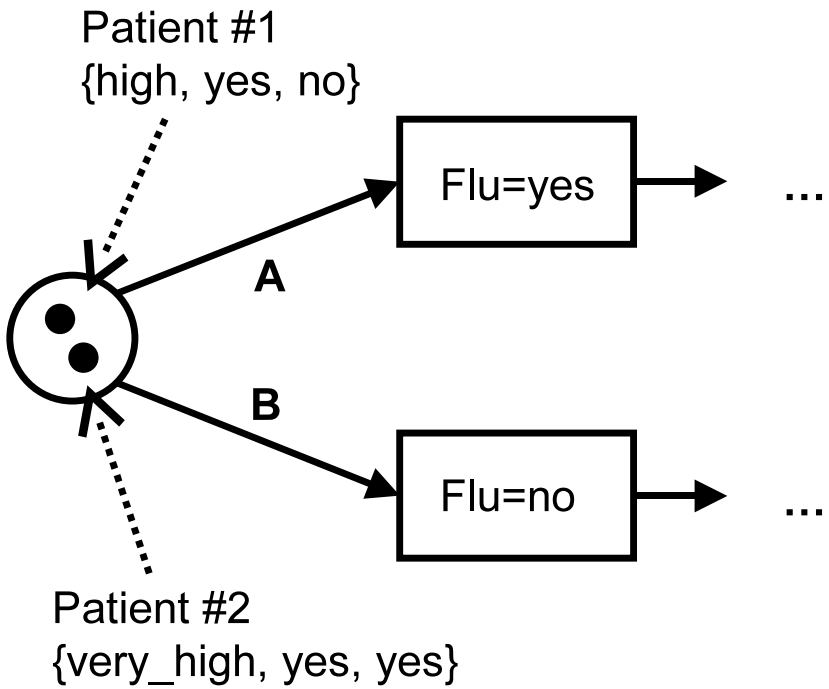
An OR-Split as Decision Point

A decision table of two patients showing different symptoms:

#	Temperature	Headache	Nausea	Decision: Flu
1	high	yes	no	yes
2	very_high	yes	yes	yes



How to Deal with Rough Decision Tables?

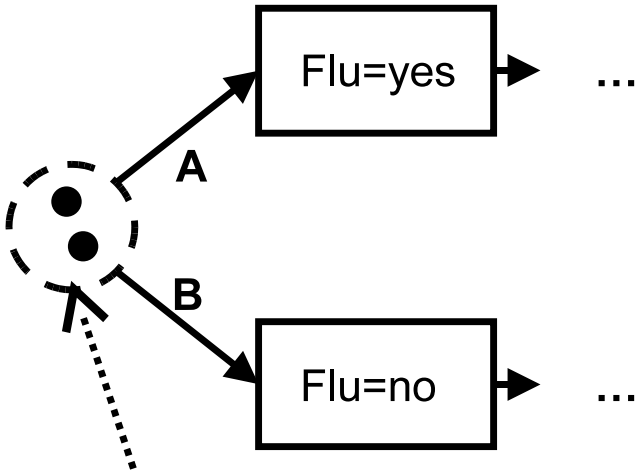
A rough decision table [Grzymala-Busse 2004]:

#	Temperature	Headache	Nausea	Decision: Flu
1	high	yes	no	yes
2	very_high	yes	yes	yes
3	high	no	no	no
4	high	yes	yes	yes
5	high	yes	yes	no
6	normal	yes	no	no
7	normal	no	yes	no
8	normal	yes	no	yes

- **Upper Approximation.** {high, yes, yes}: #4, #5 and {normal, yes, no}: #6, #8
- **Lower Approximation.** {flu=yes}: #1, #2 and {flu=no}: #3, #7

Insufficient Decision Rule at a Place

- The decision rule at the place is insufficient to deal with all tokens: #4, #5, #6 and #8 get stuck.
- We say that the place belongs to the upper approximations of both sets {Flu=yes} and {Flu=yes}, indicated a "dashed circle" place notation.

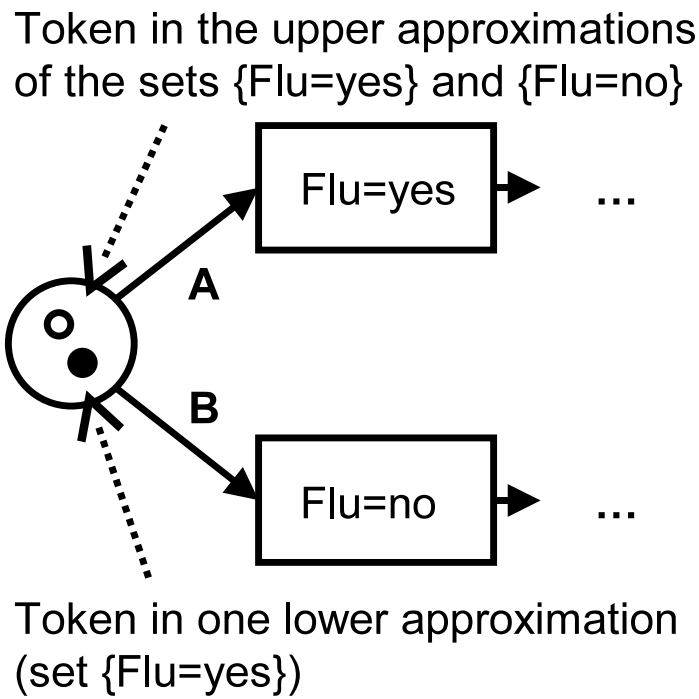


Tokens Carrying Incomplete Information

- Consider a patient phoning a General Practitioner (GP). The patients reports that she/he suffers from headache and nausea. However, she/he has not been able to check her/his temperature before phoning the GP.
- Formally the information provided can be described as: $\{?, \text{yes}, \text{yes}\}$.
- Since information is missing the GP cannot continue the treatment.
- In such a case we assign the token to the upper approximation.

Graphical Representation of Rough Tokens

- To graphically distinguish between tokens (patients) belonging to a lower or upper approximations they are represented as "hollow" tokens for those in the upper approximation.



Relationship between Rough Places and Rough Tokens

- The main difference between the rough places and rough tokens is related to who is responsible when a token gets stuck at an OR-split.
- In the first case discussed above the token carries all the required information. However, the firing rules at the OR-split are insufficient to take a decision. Therefore the responsibility is at the OR-split.
- In the second case the token cannot provide the requested information. Therefore the token is accountable for its inability to proceed further, so it can be regarded as token in an upper approximation.

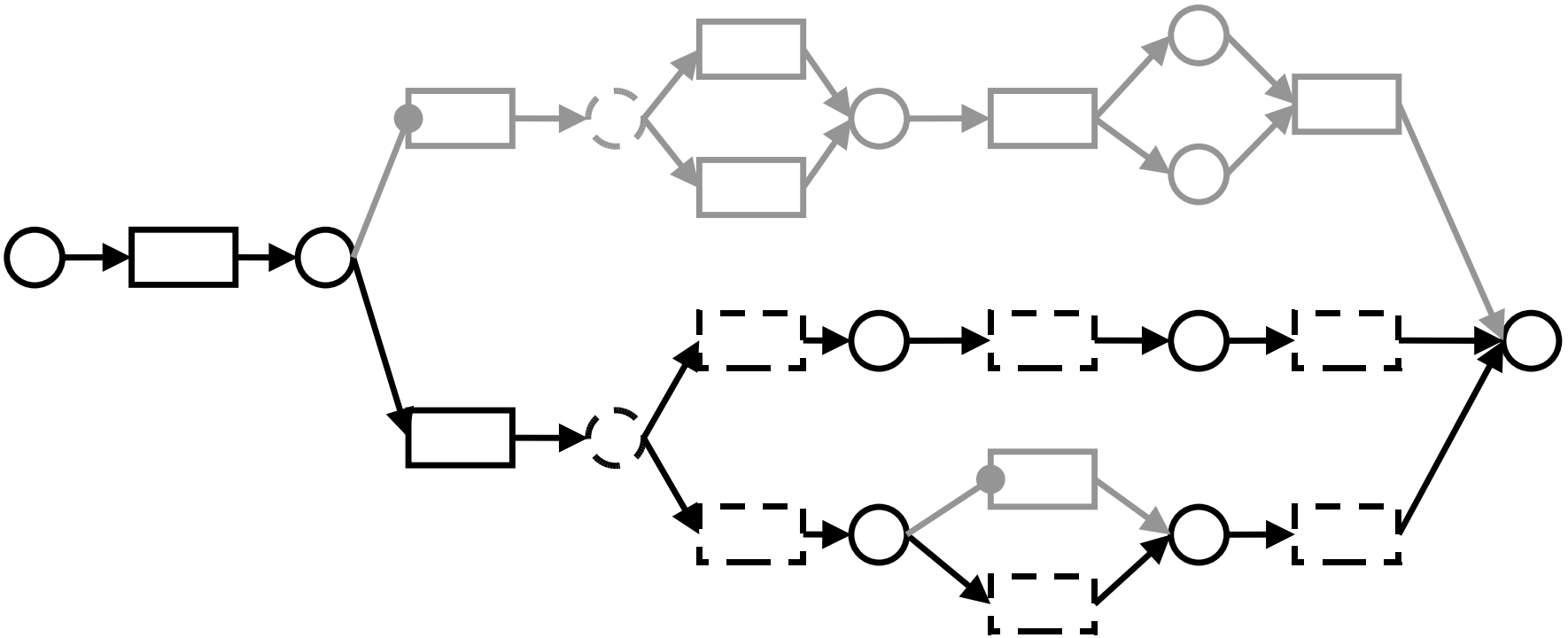
Definition of Rough Transitions

- A token can only proceed when both the token as well as the place the token is assigned to belong to lower approximations. In this case the decision rule at the OR-split has sufficient information and a transition is enabled to fire.
- However, when a token belongs to an upper approximation and/or the place belongs to an upper approximation then the token gets stuck. It is not defined which of the transitions may fire. This leads to the concept of rough transitions.

Graphical Representation of Rough Transitions

- Black solid-lined transitions will surely fire.
  Therefore they belong to the lower approximation of the set {fire=yes}.
- The grey transition surely won't fire.
  Consequently they belong to the lower approximation of {fire=no}.
- The status of remaining dashed transition is unclear.
  They may or may not fire.
  So they belong to both upper approximations of the sets {fire=yes} and {fire=no}.

An Example for Rough Transitions



Applications to Workflow Systems

- **Rough places: incomplete decision rule.** (1) Poorly designed workflow system. (2) The exceptions would intentionally be "caught" in the upper approximation of a place and presented to the end user for further special treatment.
- **Rough tokens: incomplete case information.** Provide early warning of potential delays within a workflow system.
- **Rough transitions: incomplete path information (resource management).** The concept of rough transitions supports to more efficiently manage resources.

Conclusion

- The main purpose is to utilize rough set theory to make incomplete information visible in order to deal with such a situation efficiently. In the first case, i.e. too much information, the rough concept of reducts can be applied. In the later case we identified three different occurrences: (1) incomplete decision rules, (2) incomplete case information and (3) incomplete path information.
- The central advantage of the application of rough sets is that we can draw from a rich theoretical concept to efficiently manage such situations. Our future research will concentrate on a more formal incorporation of these concepts into Petri Net theory and workflow management.